ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY W. H. MAW AND B. ALFRED RAWORTH.

VOL. CI.—FROM JANUARY TO JUNE, 1916.

London:

OFFICES FOR ADVERTISEMENTS AND PUBLICATION—35 & 36, BEDFORD STREET, STRAND, W.C.

1916.

CAL RO
EIVED
27 1916 Engineering Library
OF MICH

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CI.—No. 2610.] LONDON: FRIDAY, JANUARY 7, 1916. [Registered at the General Post Office as a Newspaper.] PRICE...6d. BY INLAND POST..8d.

eling & Porter, Ltd.,
ROCHESTER, KENT,
and 72, CANNON STREET, LONDON.
I ROLLERS. ROAD LOCOMOTIVES.
TEAM CULTIVATING MACHINERY.
I WAGONS. TRACTORS.
CEMENT-MAKING MACHINERY. 4621

G. Mumford Ltd.,
VER STREET WORKS, COLCHESTER.
N ADMIRALTY AND WAR OFFICE LISTS.
ES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, page 24.
WATER-TUBE BOILERS,
AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. Od 2179

Cranes.—Electric, Steam,
HYDRAULIC and HAND.
of all types and sizes.
GEORGE RUSSELL & CO., LTD.,
Motherwell, near Glasgow. 4319

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 4457
See Advertisement last week, page 75.

Plenty and Son,
LIMITED.
MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9083

Gas Fired Furnaces.
4640
MONOMETER MANUFACTURING CO., LTD.,
WHITEHOUSE ST., ASTON, BIRMINGHAM.
See Advert. page 42, Dec. 24.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD.,
ENGINEERS, NEWCASTLE-ON-TYNE. 4321

Special
ELECTION OF MACHINE TOOLS. See page 49.
JOHN MACNAB,
MARY STREET,
HYDE. 4039

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS,
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, GLASGOW. Od 3547
Registered Office: 108A, Cannon St., London, E.C.

Fuller, Horsey, Sons & Cassell,
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS,
11, BILLITER SQUARE, LONDON, E.C. Od 1554

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Od 9753

Marine Boiler (New), 8 ft.
6 in. dia. × 8 ft. 3 in. long, for 150 lb. w.p.
Economic Multitubular
BOILERS (New).
One 9 ft. 0 in. dia. × 14 ft. long, 150 lb. w.p.
One 8 ft. 6 in. " × 14 ft. " 150 lb. "
One 8 ft. 0 in. " × 14 ft. " 160 lb. "
One 6 ft. 6 in. " × 11 ft. " 160 lb. "
DESPATCH THREE WEEKS. Large heating surface, high evaporation, economy of space.
One Powerful Economic
MULTI-TUBULAR BOILER (Second-hand), 9 ft. 9 in. dia. by 14 ft. 6 in. long, suitable for 160 lb. w.p. DESPATCH IMMEDIATELY. 4934
JOHN THOMPSON, Boiler Works, Wolverhampton.

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS,
GLASGOW (formerly of POPLAR, LONDON),
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF
Exceptional Shallow Draught.
VESSELS PROPELLED BY STEAM
Turbines or
Internal Combustion Engines. Od 8759

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches, or Barges,
Built complete with Steam, Oil or Petrol Motors; or Machinery supplied. Od 3551
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 37, Dec. 17. 4336

Oil Fuel Appliances.
SYSTEMS { PRESSURE, AIR, STEAM.
FOR BOILERS OF ALL TYPES.
Kermodes Limited,
35, THE TEMPLE, DALE STREET, LIVERPOOL; and
100, FENCHURCH STREET, LONDON. 4078
NAVAL OUTFITS A SPECIALTY.

Locomotive Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED,
Boyne Engine Works, Leeds. Od 2487
See their Illustrated Advertisement page 81, last week.

R. Y. Pickering & Co., Ltd.
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office:
3, VICTORIA STREET, WESTMINSTER, S.W. 8353

Machine and Engineering
WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROSSER & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT ACT.—ROSSER & RUSSELL, Ltd., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9211

Two 200 KW. Westinghouse
ALTERNATORS and EXCITERS, Two-phase, 50 periods, 2200 volts, 334 r.p.m.
Two Bellies D.C. 275 KW. SETS, 500 volts. Two Bellies 160 KW., 220 volts.
A.C. MOTORS, new, from 10 to 35 HP., 500 volts three-phase, 50 periods.
JENNINGS,
West Walls, Newcastle-on-Tyne. 4576

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON AND TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 4406

THE WELL-KNOWN
Fine Red Moulding Sand,
FOR
IRON, BRASS, ALUMINIUM.
APPLY,
Mansfield Sand Co., Ltd.,
MANSFIELD, NOTTS. 9664

John Bellamy, Limited,
MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes, Iron and Steel.
Edwin Lewis & Sons, 4923
London Office:
143, Cannon St., E.C. Wolverhampton.

Tubes and Fittings,
Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 40. 4332

Locomotives in Stock.—
KERR, STUART & CO., LTD., have in stock or in an advanced state of progress at their California Works, Stoke-on-Trent, a large number of LOCOMOTIVES, with cylinders from 6 in. to 16 in. diameter (inclusive), for all gauges from 18 in. to 4 ft. 8½ in.—Apply to KERR, STUART & CO., LTD., 5, Broad Street Place, E.C. 4670

"Thompson" Boilers
IN STOCK.
Two 30 ft. by 9 ft. 3 in. by 160 w.p.
Two 30 ft. by 8 ft. 6 in. by 180 w.p.
Four 30 ft. by 8 ft. 3 in. by 160 w.p.
Three 30 ft. by 8 ft. 3 in. by 100 w.p.
Two 30 ft. by 7 ft. 3 in. by 120 w.p.
Forty other sizes and pressures.
John Thompson,
WOLVERHAMPTON. 4850
THE GLASGOW ROLLING STOCK AND PLANT WORKS.

Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS, ELECTRIC CARS and EVERY OTHER DESCRIPTION OF RAILWAY AND TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON AND BRASS CASTINGS.
Registered Office and Chief Works: Motherwell.
Cardiff Office: Gordon Chambers, 31, Queen Street.
London Office: 14, Leadenhall Street, E.C.
See Illustrated Advt. in alternate issues. Od 3392

Steel Foundry For Sale.
The BUSINESS of C. W. ROBINSON & CO., LTD. at Forth Bridge Steel Works, Polmont Station.
The Ground extends to three acres, and is held clear of burdens.
The Works are equipped with a 5½ ton Siemen's Open Hearth Furnace and 12 Crucible Pot Holes.
To effect an immediate sale a very low price will be entertained.
Apply:—
McCLELLAND, KER & CO. C.A.,
115, St. Vincent Street, Glasgow. 4836

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS. 4650
N. v. Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON, E.C.
See half-page Advertisement, last and next week.

Mechanics and Metals
National Bank
OF THE CITY OF NEW YORK.
ESTABLISHED 1810.
CAPITAL (Fully Paid) - - - $8,000,000
SURPLUS & UNDIVIDED PROFITS $9,000,000
This Bank receives Accounts of Banks, Bankers, Corporations, Firms and Individuals on favourable terms, and grants to its depositors every facility consistent with prudent and conservative banking methods.
CORRESPONDENCE INVITED.
FOREIGN DEPARTMENT.
Finances Exports and Imports, Buys and Sells Foreign Exchange, Telegraphic Transfers, &c., and makes Collections on all parts of the world.
LONDON BANKERS.
LONDON JOINT STOCK BANK, LTD.
LONDON CITY & MIDLAND BANK, LTD. 4773

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM AND GAS KETTLES. } Row's Patents.
Merrill's Patent TWIN STRAINERS for Pump Suctions
SYPHONIA STEAM TRAPS. REDUCING VALVES
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 4924

Yarrow Patent
Water-Tube Boilers.
4331
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

RAILWAY CARRIAGES, ELECTRIC CARS, &c.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

Taylor & Challen, Ltd.,
BIRMINGHAM. 3196
Presses for Sheet Metal
PRODUCTS.
See Advertisement, Dec. 17, page 55.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, Dumbarton. 4035
See Full Page Advt. page 52, Dec. 17.

Petter Oil Engines.
Manufactured by 3501
PETTERS LIMITED, Engineers, Yeovil.

Head, Wrightson & Co.,
LIMITED.
See Advertisement page 27, Dec. 24. 2403

Cement.—Maxted & Knott,
LTD., Consulting Engineers to the British Portland Cement Manufacturers, Ltd., ADVISE GENERALLY on proposed Cement Schemes FOR ABROAD. ADVICE ONLY. Highest references. Established 1890.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy," Hull. 3022

CHANTIERS & ATELIERS
Augustin-Normand
67, ru de Perrey—LE HAVRE
(France). 3390
Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Cement Plants.
Rotary Kilns, Wet and Dry Grinding Mills, Dust Collecting, Elevating and Conveying Machinery, &c.
ROCHESTER ENGINEERING COMPANY, LTD., ROCHESTER, KENT. 4722

Punch and Shear Machine
SPECIALISTS. 4784
Consult us. "The Best and the Cheapest." Large Stock. Satisfaction Guaranteed. Established 1860.
SCOTT BROS., WEST MOUNT, HALIFAX.

Rubber MANUFACTURERS
Belting
GUTTA PERCHA & RUBBER, LIMITED
Toronto - - Canada. 4520

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 4781
See half-page Advertisement page 64, Dec. 31.

The Manchester Steam Users' ASSOCIATION.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam.
9, MOUNT STREET, MANCHESTER.
Chief Engineer: C. E. STROMEYER, M.I.C.E.
Founded 1854 by Sir W. FAIRBAIRN.
Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 4498

Inst. C.E., Inst. Mech. E., and all Engineering Exams. Correspondence coaching by practical engineers. I.C.E. successes 264 out of 292. Two Bayliss Prizes, "Proxime Accessit." Special features for foreign candidates. Write for booklet, &c.—Address, 3548, Offices of ENGINEERING.

A. M.I.C.E., A.M.I.M.E., A.M.I.E.E., and Stud. I.C.E. TUITION. Correspondence and Oral. 90 per cent. successes in last eight examinations. Aeronautical Engineering, Propellers, Graphic Statics. Variable Planes.
PENNINGTONS' University Engineering Tutors, 284, Oxford Road, Manchester. 4327

TENDERS.

BANNER MOTORS, LIMITED (In Liquidation).

The undersigned is prepared to receive

Tenders for the Purchase of the ASSETS, including the following valuable Patents relating to "INTERNAL COMBUSTION ENGINES":—

Great Britain,	No. 25379/11.
United States,	1096-52/14.
Great Britain,	10763/09.
Great Britain,	10874/00.
France,	415628/10.
Germany	497281/10.
(Design Patent)	
United States,	1033599/12.
Italy,	342/125/10.
Belgium,	230628/10.
United States,	700241/02.
United States,	715150/02.

For full particulars apply to—
RALPH S. MORRISH,
Chartered Accountant.
St. Michael's House,
Cornhill, London, E.C. D 267

APPOINTMENTS OPEN.

BOROUGH OF SWINDON EDUCATION COMMITTEE.

SWINDON AND NORTH WILTS SECONDARY SCHOOL AND TECHNICAL INSTITUTION.

Principal: Mr. G. H. BURKHARDT, M.Sc.

The Committee invite

Applications for the Perma- nent APPOINTMENT of HEAD of the ENGINEERING DEPARTMENT of the Technical Institution. Salary £200 per annum, rising with approved service by £10 p.a. to £250 p.a. Candidates must be ineligible for military service. Teaching experience, including laboratory work, and practical experience in an engineering works essential, and ability to take some electrical work (during the period of the War) desirable.
Further particulars, if definitely specified, will be supplied by the Principal.
Immediate application to be made to the Principal, Technical Institution, Swindon.
W. SEATON,
Secretary to the Education Committee.
28th December, 1915. D 259

COUNTY BOROUGH OF WEST HAM.

PLAISTOW FEVER HOSPITAL.

The Council of the County Borough invite

Applications for the Post of ENGINEER at their Fever Hospital, Samson Street, Plaistow.
Applicants must not be of military age.
Salary £150 per annum.
The person appointed will be required to devote his whole time to the service of the Council, and will have charge of all boilers, plant, machinery and fittings, &c., and must keep in repair and good running order various motor vehicles used for the purposes of the Hospital.
Further and fuller particulars as to duties may be obtained, together with an Application Form, at my Office at the Town Hall, West Ham.
Applications, enclosed in the envelope provided, must be delivered to me not later than Noon, Wednesday, the 19th January, 1916.
Canvassing members of the Council is prohibited, and will disqualify for the appointment.
By Order of the Council.
GEO. E. HILLEARY,
Town Clerk.
Town Hall, West Ham.
3rd January, 1916. D 289

INDIAN PUBLIC WORKS AND STATE RAILWAY DEPARTMENTS.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL will, in 1916,

Appoint a Number of ASSISTANT ENGINEERS to the Indian Public Works and State Railway Departments.
Candidates must be British subjects, and, save as provided in Appendix III to the Regulations, must not be less than 21 and not more than 24 years of age on the 1st July, 1916. They must have either obtained one of certain recognised University degrees or other distinctions in Engineering, or have passed the Associate Membership Examination of the Institution of Civil Engineers.
Applications must reach the India Office by 1st April, 1916. Printed Forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, Public Works Department, India Office, London, S.W.
India Office, London.
December, 1915. D 69

Old-Established Insurance Company REQUIRES First-class ENGINEER-SURVEYOR, for Yorkshire.—Address, in confidence, with full particulars, D 314, Offices of ENGINEERING.

Wanted, Factory Manager (ineligible), for an important chemical works. Must be competent engineer, with thorough knowledge of chemistry and a good organiser. Only those need apply who have had previous large experience. —Apply, by letter, giving full particulars of past experience (in confidence) and salary required, to Z., care of DAVIES & Co., Advert. Agents, Finch Lane, E.C. D 303

Wanted, Experienced ENGINEER, to take charge of large works in Midlands. Government controlled. Must thoroughly understand all types of machines and electric plant. State experience, age and salary.—Address, D 300, Offices of ENGINEERING.

Shift Engineers.—Wanted, at the London County Council's Outfall Works, Crossness, Abbey Wood, S.E., Four SHIFT ENGINEERS, to take charge of triple expansion high speed centrifugal pumping engines. Candidates must be skilled mechanics, and must be ineligible for military service. — For particulars, apply to the SUPERINTENDENT, L.C.C. Outfall Works, Crossness, Abbey Wood, London, S.E. D 323

Temporary Assistant Engineer WANTED, immediately, by the Port of London Authority. Applicants must have passed the examination for Associate Membership of the Institution of Civil Engineers, and had experience in railway, dock and harbour works, or with public works contractors. Preference will be given to men ineligible for military service.
Applications must be on the prescribed Form, obtainable at the Office of the CHIEF ENGINEER, 109, Leadenhall Street, London, E.C., and must be delivered at that Office, accompanied by copies of not more than three recent testimonials, not later than Ten a.m. on Tuesday, 18th January, 1916. D 273

Experienced Accountant WANTED, for war service, with engineering firm in North London; one capable of taking charge of firm's books. A man who is ineligible for military service or not at present on war work preferred. Permanent position for suitable applicant.—Apply, by letter, stating age, experience, and salary required, D 294, Offices of ENGINEERING.

Editorial Vacancy on the sub-editorial staff of a weekly journal. A man is wanted with knowledge of motor haulage for business purposes, in conjunction with technical knowledge. Good prospects.—Address, giving full particulars, D 321, Offices of ENGINEERING.

Wanted, Immediately, by large engineering company on the North-East Coast, DRAUGHTSMAN DESIGNER; fully competent to design pneumatic or electrical coal cutting machinery. Anyone already engaged on Government work need not apply. — Apply, with references, to your nearest LABOUR EXCHANGE, mentioning this Journal, and D 298.

Draughtsmen (Senior and Junior), for urgent Government aeronautical work. Must have had several years shop and drawing-office experience, also some technical training. Men used to automobile work preferred. Good salary and prospects; overtime paid for. No man on Government work need apply.—Write or apply, your nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper and No. A 1313. D 276

Draughtsman Wanted for general work, knowledge of vacuum plant and chemical engineering an advantage, but not essential. State experience, age and salary required.—Address, to D.P. DEPT., Messrs. LEVER BROTHERS LIMITED, Port Sunlight, Cheshire. D 260

Draughtsmen, Experienced, WANTED, for engineering works, North-East Coast District. Those having experience in marine or turbine work preferred. No person already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal, and D 299.

Wanted, Experienced MACHINE TOOL DRAUGHTSMAN. No person already employed on Government work will be engaged.—Apply, giving full particulars, to nearest LABOUR EXCHANGE, mentioning this Journal, and D 302.

Wanted, Young Engineer, as junior draughtsman, in London. Must have had workshop experience, and be ineligible for Army and not on Government work.—Apply, stating age, experience, and salary required to your nearest LABOUR EXCHANGE, mentioning this paper and No. A 1312. D 282

Wanted, by a Large Engi- neering Firm in the North of England, a TOOL-ROOM FOREMAN, for the control of about 40 men; used to accurate work, jigs and capstan tools. No person on Government work will be engaged.—Apply, your nearest LABOUR EXCHANGE, mentioning this paper and No. A 1301. D 281

Foreman, for London Iron- foundry engaged on Government work; must be thoroughly experienced. No one already on Government work need apply.—Write, stating age, experience, and salary required, to your nearest LABOUR EXCHANGE, mentioning this paper, and No. A 1314. D 306

Advertising.—Firm of En- gineers, making well-known speciality, REQUIRE the SERVICES of a YOUNG MAN, for advertising work. Must be able to draw up smart "copy," and should have a knowledge of photography. —Address, stating salary and experience, sending a few samples of work, D 286, Offices of ENGINEERING.

Wanted, Immediately, for Government work, SIX experienced RATE-FIXERS and ESTIMATORS, used to getting out material estimates from drawings, and well up in speeds and feeds. No one already engaged on Government work need apply.—Apply, giving full experience, qualifications and salary required, to your nearest LABOUR EXCHANGE, mentioning this paper and No. A 1305. D 275

Ratefixers and Estimators REQUIRED by large firm of motor engineers in Midlands; must be first-class mechanics of proved ability. Liberal salary to competent men, but no one engaged upon Government work will be engaged. —Apply, giving full particulars of experience, age, remuneration, &c., to nearest LABOUR EXCHANGE, mentioning this paper and No. A 1298. D 268

Munition Factory Requires several JIG and TOOL MAKERS, also INSTRUMENT MAKERS and TURNERS, willing to learn to Operate and Set-up Cleveland, Gridley, and Brown and Sharpe automatic machines. No person already engaged on Government work will be considered.—Apply, in first case, to the nearest LABOUR EXCHANGE, mentioning this Journal and C 870.

Wanted, for Engineer and Patent Agent's Office in Westminster, smart JUNIOR ASSISTANT, with drawing-office experience. No person resident more than 10 miles away, or already engaged on Government work, will be engaged.—Address, D 320, Offices of ENGINEERING.

Consulting Engineer has VACANCY for YOUTH; preferably one having passed through technical college course. No premium. Small salary to commence. — Address, M.I. Mech. E., care of Wm. DAWSON & SONS, 121, Cannon Street, London, E.C. D 319

Engineering Pupil.—Vacancy with Firm (Government Contractors) manufacturing latest types of machinery, oil and gas engines, &c.; moderate premium.—Address, 6521, Offices of ENGINEERING.

Pupil. — The Borough and Waterworks Engineer (A.M.I.C.E.), of Leamington, has a VACANCY in his office for a PUPIL.—Address, TOWN HALL. C 342

A Large Firm of Engineers, in the Midlands, have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of ENGINEERING.

SITUATIONS WANTED.

Factory Management and Business Control.—Well-known practical and technical expert, with 20 years' experience in management of high-class small arms and repetition manufacture, is OPEN for ENGAGEMENT. Salary £800 to £1000.—Address, D 295, Offices of ENGINEERING.

Assistant Works Manager (age 24), at present controlling tool room and machine departments of high-class small arms and repetition factory in Midlands, SEEKS CHANGE, in similar capacity; technical education, with sound practical experience. Salary £200 to £250.—Address, D 296, Offices of ENGINEERING.

M. I. Mech. E. (aged 42), with 14 years' experience in management of large works now employing over 1400 hands (skilled and semi-skilled), on small accurate repetition work, REQUIRES similar POSITION, or as general manager. Used to control of men, and well up in labour problems. Speaks French, and has business ability, as well as thorough practical and technical college training. Disengaged early February.—Address, D 274, Offices of ENGINEERING.

A. M.I.C.E. (44), Unsuccessful in obtaining commission although passed for active service, SEEKS APPOINTMENT as engineer or representative of sound engineering business, at home or abroad; 25 years' railway and general, maintenance survey and construction experience. Good organizer. Fluent French and Hindustani.—Address, D 293, Offices of ENGINEERING.

Mechanical Engineer, 24 years' experience shops and office, SEEKS fresh ENGAGEMENT, home or abroad, end of May; leaving present position on South American railways, 6½ years, for private reasons.—Address, D 208, Offices of ENGINEERING.

Experienced Engineer, Rail- way location, construction and administration, concrete construction, hydraulic and general engineering, ineligible for Army, SEEKS POSITION. Fluent Spanish. Would go abroad.—Address, D 272, Offices of ENGINEERING.

Translator.—French Natural- ised British subject, many years' experience as technical translator, French, German, and several other languages, special knowledge of patent and engineering business, SEEKS ENGAGEMENT.—Address, D 240, Offices of ENGINEERING.

Civil Engineer (42) Seeks more responsible POSITION. Home or France. 22 years' experience all branches (including mining, boring and cottage architecture). Exceptional references.—Address, D 243, Offices of ENGINEERING.

Engineer (32), A.M.I. MECH. E., SEEKS permanent POSITION as works engineer, representative, chief inspector, or head draughtsman. Experienced in maintenance, production, testing, and control of men. Salary £250-£300. Near London preferred.—Address, D 285, Offices of ENGINEERING.

Engineer, First-class B.o.T., Cert. high speed, steam, and internal combustion engine experience, REQUIRES responsible POSITION, munition work or Government-controlled establishment.—Address, D 270, Offices of ENGINEERING.

Engineer (41), with shops, draughting, sea, and commercial experience in Scotland and U.S.A., WILL be OPEN about April for ENGAGEMENT in Great Britain, Continental Europe or British Colony. Experienced in marine and general mechanical engineering, manufacturing, jobbing and repairs; some experience in structural steel. Former positions: leading draughtsman on marine engines, assistant-superintendent, general engineering works, 1500 men; manager, general engineering works, 100 men.—Address, ENGINEER, care of H. R. STAULDING, 932-934, Folsom Street, San Francisco, U.S.A. D 318

Young Mechanical and Elec- trical Engineer, 19 years' experience, technical college, works, drawing-office, commercial, DESIRES CHANGE. Would represent British or American firm in London.—Address, D 288, Offices of ENGINEERING.

Junior Draughtsman, Good general experience, quick tracer, REQUIRES MUNITIONS WORK, attested under Derby Scheme. —F.P., Wix Lane, Clapham Common, London, S.W. D 308

I Want a Start as Mechanical Draughtsman, where I can do as previously—*i.e.*, get to the top purely on my own abilities.—Address, D 297, Offices of ENGINEERING.

Internal Combustion Engine Designer (26), thoroughly experienced gas, semi-Diesel oil internal combustion loco, wood refuse plants, &c.; ineligible for Army.—Address, D 307, Offices of ENGINEERING.

Required, Apprenticeship, by youth (16) for thorough practical training in motor engineering. Small premium if necessary.—Address, D 305, Offices of ENGINEERING.

PARTNERSHIPS.

Every Engineer desiring a **Partner** or a **Partnership** should write fully to WHEATLEY KIRK, PRICE & CO., 46, Watling Street, LONDON, E.C., Albert Square, Manchester, or 4338 26, Collingwood Street, Newcastle-on-Tyne.

Mechanical Engineer Wants PARTNERSHIP in a well-established concern in or near London. Wide experience, and capital up to £4500. Business must show good past profits and be open to investigation.—Address, D 310, Offices of ENGINEERING.

A Director is Required who will invest £5000 in an engineering company, London, manufacturing a very well known Continental aeroplane engine, the rights of which they control. A year's work in hand, open to closest investigation. —Particulars from Messrs. ARNOLD & CO., 76, Cannon Street, London, E.C. D 315

Engineer Required as Active Director, with £5000, to take half share in a well-established business in the Provinces, controlling electric power and light companies, showing very good net profits and open to every investigation.—Particulars from Messrs. ARNOLD & CO., 76, Cannon Street, London, E.C. D 316

PATENT AGENTS.

The Consulting Patent AGENCY, 253, Gray's Inn Road, London. Regd. British, U.S.A., and Canadian Agents. "Cepators, London" — Holborn 6109. All matters at fixed inclusive charges. 4449

Jensen and Son, 4284
CHARTERED PATENT AGENTS,
(Established 1867). British, Colonial, and Foreign Patents, and Trade Marks and Designs Registrations, 77, Chancery Lane, London, W.C. Tel.: Holborn 1240.

John E. Raworth,
CHARTERED PATENT AGENT,
70/71, Queen Anne's Chambers, 4340
Tothill Street, Westminster, S.W.

PUBLICATIONS.

PATENT-RIGHTS;
THEIR ACQUISITION AND MAINTENANCE.
A Concise Summary of the Principal Facts with which Inventors, Manufacturers and others, interested in the Protection of Inventions, should be acquainted.
By G. G. M. HARDINGHAM,
Mem. Inst. M.E., Fel. Cn. Inst., P.A.
CROSBY LOCKWOOD & SON, 4028
7, STATIONERS' HALL COURT, LONDON, E.C.
Revised Edition, price 1s. 6d.; by post, 1s. 8d.

WANTED, &c.

Representation Wanted, in Glasgow district, by a Sheffield firm manufacturing shear blades and machine knives. Must be by an office or agent with sound connection among shipbuilders, iron and steel works, &c.—Address, D 304, Offices of ENGINEERING.

Repetition Work.—Castings and Machined Work for Munitions. FIRMS in a position to undertake such PLEASE COMMUNICATE particulars.—Address, D 273, Offices of ENGINEERING.

Manchester Engineers, with large machine tool orders approaching completion, are OPEN to RECEIVE ENQUIRIES.—Address, D 317, Offices of ENGINEERING.

Tanks Wanted.—Three or Four IRON TANKS, 12 ft. by 10 ft. by 8 ft. deep. Cheap, and in good condition.—Address, D 271, Offices of ENGINEERING.

Wanted, Immediately, New or Second-hand SCREW-CUTTING LATHES, about 4½ in. centres.—Full particulars to D 277, Offices of ENGINEERING.

Wanted, Direct Coupled STEAM GENERATOR, for an output of about 250 Kw., with 150 lb. steam pressure. Generator three-phase, 50 periods.—State voltage, age, price, and full particulars to The OLYMPIA OIL & CAKE CO., LTD., Selby. D 311

ENGINEERING.

STABLE BIPLANE ARRANGEMENTS.*

By JEROME C. HUNSAKER, S.M., Member of the American Society of Naval Architects and Marine Engineers; Assistant Naval Constructor, United States Navy.

1. *Introduction and Summary.*—It is well known that the typical cambered aeroplane wing is longitudinally unstable, whether used singly as a monoplane or in pairs as a biplane. The following is an account of a research carried out in the wind tunnel of the Massachusetts Institute of Technology with a view to discovering whether this instability may be overcome without material sacrifice of lift or increase in resistance.

It is believed that our experiments will show that the ordinary biplane, using wings of standard section, may be made longitudinally stable by giving the upper plane a stagger forward of 50 per cent. of the chord, and at the same time inclining its chord about 2½ deg. to the lower chord, "decalage" 2½ deg. The loss in maximum lift to drift ratio ("efficiency") is less than 5 per cent.

The maximum possible lift is not diminished, but increased slightly. The landing speed of the aeroplane is thus the same whether this arrangement or the ordinary one be used. Furthermore, the maximum speed, which is limited by the drift at the value of lift necessary to sustain the weight of the aeroplane, is identical in both cases. Hence, by the proposed alteration in wing arrangement, an existing biplane should be practically unaffected in performance while it has been made immensely more safe to fly. In practice, the unstable pitching moments of ordinary biplane wings (orthogonal biplane) are balanced by a large horizontal tail surface. The increased structural weight due to inclined struts in a staggered biplane should be compensated, at least in large part, by the saving in weight due to a smaller tail surface and lighter supporting structure.

Both the monoplane and orthogonal biplane arrangements show a critical angle or "burble point" beyond which, if the angle of the chord to the wind be increased, the lift drops off. Such a machine may easily be "stalled" in the air if the pilot attempts to head up too steeply, when it will sink instead of climb. The probability of stalling is not directly affected by the stability or instability of the aeroplane, but, of course, its effects are less disastrous if the machine be stable. If the curve of lift on angle at the burble point be flat, the probability of stalling is greatly reduced. The staggered biplane with 2½ deg. decalage is shown by the diagram,† Fig. 12, to have a fairly flat burble point. Thus the burble point comes at 20 deg., but the drop in lift to 24 deg. is only 3 per cent.

The orthogonal biplane has an early burble point at 14 deg., with a drop in lift of 5 per cent. to 18 deg. A greater degree of longitudinal stability may be obtained by greater decalage of the upper wing, but a material loss in lift must be expected. On the other hand, a decalage of only 1 deg. gives a neutral wing, practically equal in lift to an orthogonal biplane.

An alternative arrangement was tested in which the lower wing chord was made 83 per cent. of the upper, stagger 50 per cent., decalage 2.1 deg. This type 3A is stable for a low centre of gravity, or neutral for a high centre of gravity. The maximum lift-drift ratio is about 5 per cent.

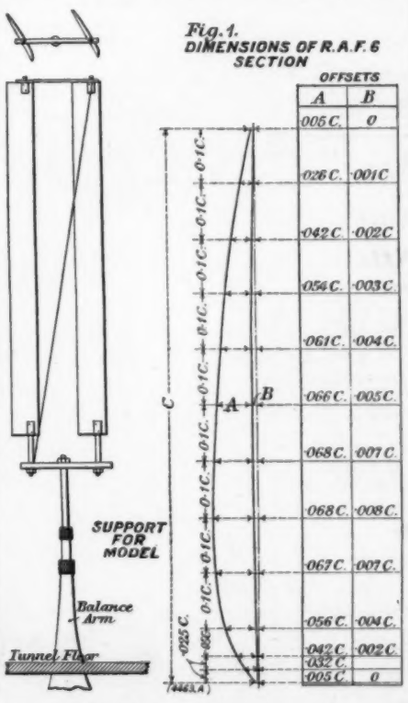


Fig. 1.
DIMENSIONS OF R.A.F. 6 SECTION

less than the ordinary biplane; the maximum lift is 3 per cent. greater. At high speeds corresponding to a small value of lift coefficient, the type 3A offers about 5 per cent. more resistance. At low speeds, however, the resistance for given lift is about 10 per cent. less in type 3A than in an ordinary biplane. The burble point is flat from 12 deg. to 24 deg. This is the principal advantage of this arrangement, and an aeroplane with such wings should be unlikely to stall, and a pilot should be able to land at a very low speed by using his wings as an air brake.

The combinations of stagger and decalage described above give a degree of longitudinal stability and a flat burble point without material loss of lift. The same degree of stability may be given by a suitable tail, but with attendant disadvantages of weight and resistance. Likewise, a reversed trailing edge makes a stable wing, but involves from 10 to 20 per cent. loss of lift.

The experiments here described were made with a constant gap between wings, constant span, and a particular wing section. All tests were run at 30 miles per hour. It is obvious that greater lift may be obtained by a greater gap between wings, greater span to chord ratio, and a higher value of the product wind velocity times span. Likewise, other wing sections may be more favourable than that employed, and there may be an advantage in using two wings of different sections. Also transverse overhang of the upper wing will reduce the loss of lift due to interference. No attempt has yet been made to find the best all-round arrangement. The variables in the problem have been kept a minimum, and changes made systematically to demonstrate the effect of each change. For this reason, the results should be compared strictly within the limits of the present investigation.

Longitudinal stability only is here discussed. Obviously, some degree of lateral stability is also necessary. The problem of obtaining lateral righting moments by modifications in wing arrangement has been investigated at this laboratory, and the results will shortly be published. It was found that a dihedral angle upwards of 175 deg. for the wings is equivalent to sweeping back each half wing about 15 deg. from the transverse axis of the aeroplane. Each of these arrangements was found to have no material effect on the properties of the wing, and each was found to give powerful lateral rolling moments to resist rolling and side slip. It therefore appears possible to obtain without sacrifice a wing arrangement which shall be laterally and longitudinally stable. Indeed there is good evidence that the designers of at least two foreign military aeroplanes have succeeded in obtaining inherent stability.

Stability in the sense used in this paper is static. In the theory of small oscillations the rate of change of righting moments is used instead of the actual values of those moments. However, the existence of such righting moments must first be assumed. If an aeroplane is not statically stable, or is not in stable equilibrium in steady flight, dynamic stability is impossible. But if it is statically stable, dynamic stability is not only possible, but very probable. The present investigation is preliminary to a dynamical study of flight. We are concerned with the provision of a restoring moment to resist the pitching of the machine. The damping of the pitching by a tail or other means is a separate problem, but fortunately presenting no difficulty.

2. *Model-Making and Mounting.*—Wing models of 18 in. span used in these tests were scraped from kiln-dried black walnut, finished to templet, smoothed and shellaced. The section contour,

* An account of a research conducted at the wind tunnel of the Massachusetts Institute of Technology.

† This diagram will appear in the concluding portion of the present article.

STABLE BIPLANE ARRANGEMENTS.

Fig. 2.

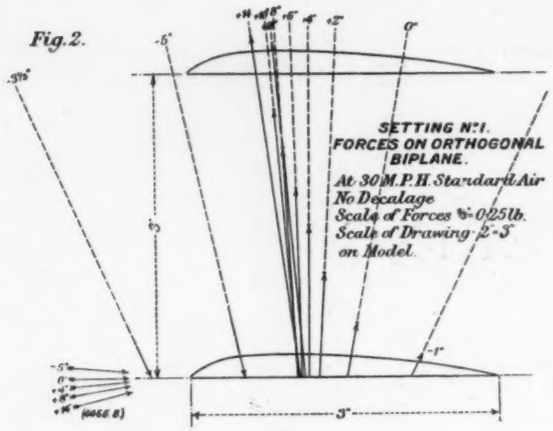

SETTING N°1.
FORCES ON ORTHOGONAL BIPLANE.
At 30 M.P.H. Standard Air
No Decalage
Scale of Forces ⅛ = 0·25 lb.
Scale of Drawing 2" = 3" on Model.
3"

Fig. 3.

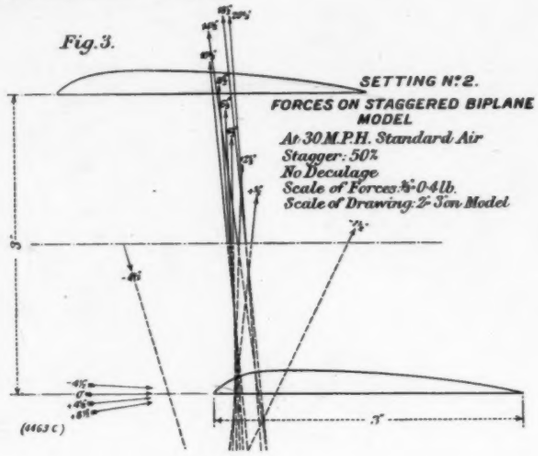

SETTING N°2.
FORCES ON STAGGERED BIPLANE MODEL
At 30 M.P.H. Standard Air
Stagger: 50%
No Decalage
Scale of Forces ⅛ = 0·4 lb.
Scale of Drawing 2" = 3" on Model
3"

Fig. 4.

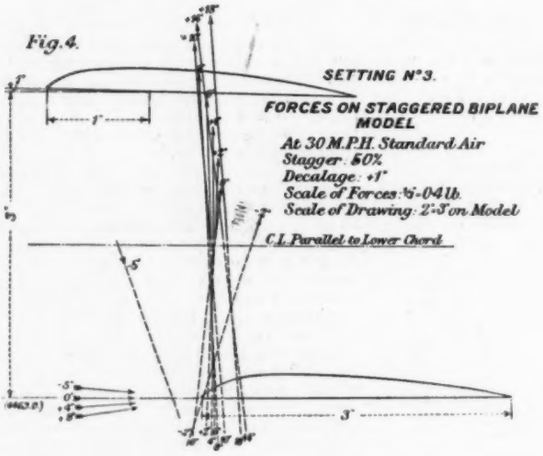

SETTING N°3.
FORCES ON STAGGERED BIPLANE MODEL
At 30 M.P.H. Standard Air
Stagger: 50%
Decalage: +1"
Scale of Forces ⅛ = 0·4 lb.
Scale of Drawing: 2" = 3" on Model
C.L. Parallel to Lower Chord
3"

Fig. 5.

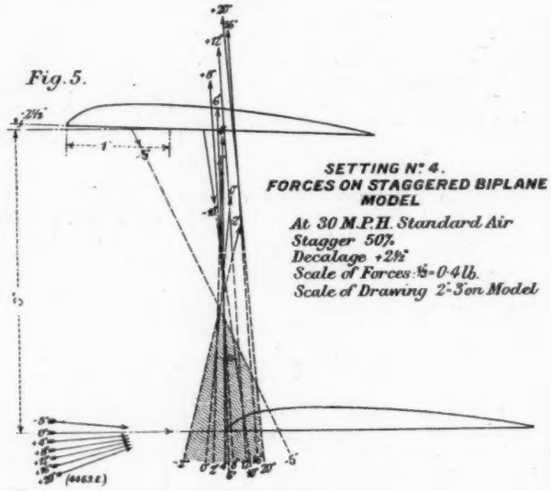

SETTING N°4.
FORCES ON STAGGERED BIPLANE MODEL
At 30 M.P.H. Standard Air
Stagger 50%
Decalage +2½"
Scale of Forces ⅛ = 0·4 lb.
Scale of Drawing 2" = 3" on Model

Fig. 6.

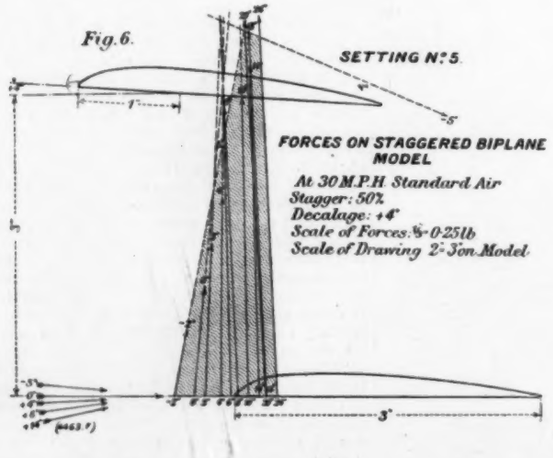
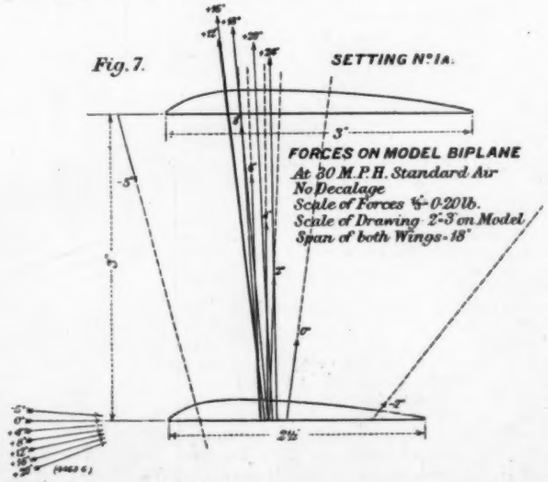

SETTING N°5.
FORCES ON STAGGERED BIPLANE MODEL
At 30 M.P.H. Standard Air
Stagger: 50%
Decalage: +4"
Scale of Forces ⅛ = 0·25 lb
Scale of Drawing 2" = 3" on Model
3"

Fig. 7.



R.A.F. 6, is believed to be correct to one-hundredth of an inch. The wing-tips were fitted with an inserted brass piece to take the screws of the supporting device. The biplane wings were mounted vertically in the tunnel as shown in Fig. 1. Lift and drift were measured on the two horizontal balance-arms, and pitching moment by a vertical torsion wire. The observed forces and moments were corrected for the effect of the supporting device determined by separate tests. The results reported therefore apply to bare wings without struts, wires, &c.

3. *Graphical Representation.*—Since the models were all held vertical, and rotated about a vertical axis only, the resultant force of the wind must lie in the horizontal plane of symmetry. The balance measured the lift or component force directed across the stream, the drift or component force directed along the stream, and the pitching moment about the vertical axis of the balance, for various angles of the wings to the wind. The axis of moments is taken arbitrarily, and since in practice one wishes to know the moments about any assumed location of centre of gravity of machine, the following method of representation of moments has been adopted:—

Let D = observed drift, L = observed lift, and M = observed pitching moment about the balance axis. The resultant force $R = \sqrt{D^2 + L^2}$. The inclination of this force to the wind direction is $\theta = \tan^{-1} \frac{L}{D}$. The perpendicular distance of this resultant force from the axis of moments is given by $X = \frac{M}{R}$. We may then locate as a vector the resultant force R in position, magnitude and direction. The location of R for various attitudes of

STABLE BIPLANE ARRANGEMENTS.

Fig. 8.

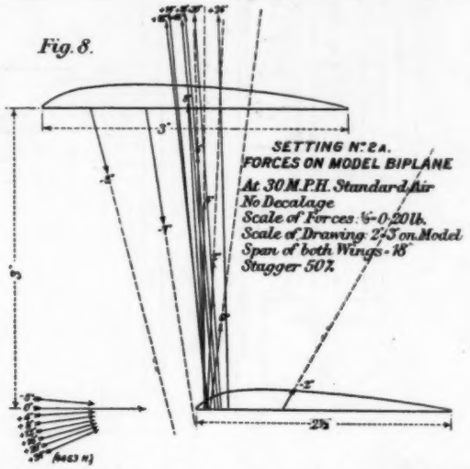
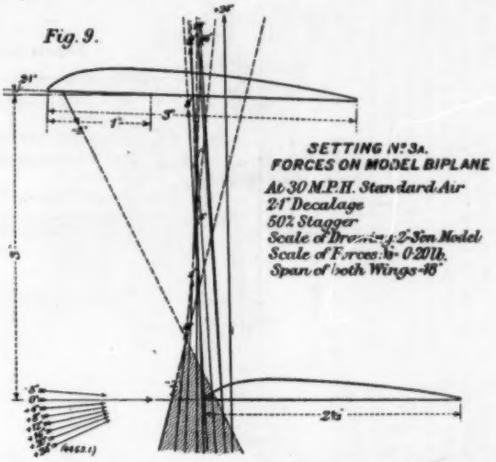


Fig. 9.



the model is shown by Figs. 2 to 9, on the opposite and present pages.

In order to avoid drawing a new model for each inclination to the wind, the model is drawn once, and considered fixed in space while the wind direction is considered to change. The resultant forces R are then located with reference to the wings. The axis of moments is of no interest and is not shown.

It should be noted that R is no physical force, but is the result of an algebraic manipulation. It should be defined as that force which, if acting, would have produced the same lift, drift, and moment as were observed. R need not intersect the model. For example, at a certain angle there may be little, if any, force, but due to eddy motion there may be a couple acting which shows as a large pitching moment. To represent both the small force and the large moment, we must draw a small R acting at a great distance from the axis of moments used. Thus, on Fig. 2, at $-3\frac{1}{2}$ deg., the resultant force lies forward of the wings.

In an aeroplane, for simplicity, let us consider that the only forces acting are due to the wings. In order to fly at an incidence of 4 deg., for example, the centre of gravity must lie on the force vector for 4 deg. There is then no moment about this point, and the machine is in equilibrium. For equilibrium, the centre of gravity may lie anywhere along the line of action of R for 4 deg. The centre of gravity once located is fixed for the machine, and usually there will be only one position of equilibrium.

Consider the orthogonal biplane of Fig. 2, with a centre of gravity on the line R 4 deg. If this machine stall to 6, 8, 10, 14 or 18 deg., the resultant forces in each case lie forward of the centre of gravity, and give a moment tending to swing the machine to greater angles. Likewise, any dive started is increased. The wings are therefore longitudinally unstable for any given position of the centre of gravity. On the other hand, consider Fig. 6 in the same manner. If the machine stall or dive, a righting moment is at once produced to throw the machine back to its former equilibrium position. Here we have stable equilibrium as distinguished from unstable equilibrium in Fig. 2.

4. *Centre of Pressure.*—It has been customary to represent the longitudinal stability of a wing by means of a so-called centre-of-pressure curve. This curve is constructed by plotting the distances from the leading edge of the intersections of the forces R with the plane of the chord. Since R is no real force, there is no real centre of pressure. Centre-of-pressure curves are hence purely artificial, and, as will be shown later on, often misleading. For example, in a combination of wings one may choose any plane on which the intersections with the forces R give a centre-of-pressure curve. On Fig. 9, intersections with the plane of the lower wing give a stable centre-of-pressure curve, while similar intersections with the plane of the upper wing give an unstable centre-of-pressure curve. In reality, the location of the centre of gravity is the governing factor. Thus, if for Fig. 9 the centre of gravity be within the shaded area below the vectors for -2 deg. and $-5\frac{1}{2}$ deg., the aeroplane is stable. If without, it is unstable for a steep dive.

For purposes of comparison, the centre-of-pressure curves are drawn in the diagrams,* Figs. 10 and 11, by plotting the intersections with a plane midway between the wings and parallel to the chord of the lower wing. This plane is chosen arbitrarily, but is the same for all models.

(To be continued.)

* These diagrams will accompany the concluding portion of this article.

THE LAKE MARGARET HYDRO-ELECTRIC POWER WORKS

THE well-known Mount Lyell mine and North Mount Lyell mine, near the west coast of Tasmania, were, at the end of last year, furnished with a supply of electric power. The mines are owned and operated by the Mount Lyell Mining and Railway Company, Limited, of 39, Queen-street, Melbourne, and Palmerston House, Old Broad-street, London, E.C. The company have reduction works at Mount Lyell, and the ore won is there treated, and yields copper, silver, and gold. The company also operates railways which link the mines with the reduction works and the reduction works with the coast. The installation of an electric supply was first mooted many years ago, and has been the subject of consideration from time to time. Owing to the growing scarcity of wood fuel and to the price of coal and other circumstances, the subject was revived in a more definite form early in 1911, and Mr. A. G. M. Michell, of Melbourne, was invited to investigate the proposals which had been made by the engineering staff of the company for the obtaining of a supply of power from Lake Margaret. Mr. Michell reported favourably on the scheme, and as a result the works which we propose to describe have been carried out, and are now in successful operation.

Mount Lyell is situated some 20 miles or so from the West Coast of Tasmania, in the country north of Macquarie Harbour. Lake Margaret is in the same district 5 miles due north of the reduction works. It has an altitude of 2150 ft. and an area of 303 acres. A general view of the reduction works is given in Fig. 1, and a view of the lake in Fig. 2, both on Plate I. The watershed which feeds the lake has an area of some $7\frac{1}{4}$ square miles, and is roughly in the form of a circular basin lying between Mounts Sedgwick, Tyndall and Geikie. The ridges and spurs which form the edge of the basin completely encircle it, except for a short gap which forms the lake outlet. The descent from this gap to the lower ground fronting the hill range is sudden and precipitous, so that a suitable head of water for electric generation is obtained in a short horizontal distance. The greatest depth of the lake is about 150 ft., but towards the outlet it has shallowed up, and the gap forming the outlet of the lake is partly closed by a natural bar of conglomerate formation, which rises well above the lake-level and bridges the gap at the very edge of the descent to the lower ground. The distance from the bar to the edge of the lake is about 12 chains, the intervening space being occupied by a marshy flat with a sandy bottom. Before the construction of the new works two streams issued from the flat, and passing one on each side of the natural bar, united below it and fell in cascades and waterfalls for a distance of some 500 ft. to a small plain below. The streams here formed the Yolande River, which ultimately flows into the Henty River, this latter entering the sea to the north of Macquarie Harbour. The whole descent is so rapid that in a distance of $1\frac{1}{2}$ miles from the lake the fall is 1100 ft. The rainfall in the watershed averages about 150 in. a year, with no marked wet or dry periods. In the winter there is some snow, but the lake never freezes over.

The power-station has been built in the valley of the Yolande River, but some distance from the foot of the falls. The position was largely dictated by considerations of accessibility in view of the heavy machinery which had to be installed. To lead the water from the lake to the station, a wood pipe-line has been laid from the lake-mouth along the hillside to a point above the station. Here the wooden pipe joins the steel pressure-pipes which carry the water to the station in the valley below. The wood pipe is more or less on a level—it has a fall of about 40 ft. in its length of 7100 ft.—while the steel pressure-pipes have a fall of 1040 ft. in a length of 2909 ft. To facilitate the carrying out of the work, a start was made by constructing a tramway to the power-station site. This was completed by the end of 1912. In addition to serving for the carriage of material and plant, this tramway was used for the transport of practically the whole of the firewood requirements of the reduction works during the construction of the hydro-electric plant. The district it passes through contains a good supply of King William pine, which is becoming scarce in the country.

To facilitate the building of the wood pipe and the dams, a wooden tram-road was also constructed on the hillside from the site of the upper end of the pressure-pipes to the lake outlet. The length was about $1\frac{1}{2}$ miles, and the total rise about 50 ft. The road skirts the sinuous outline of the hill, and in one place the work of construction involved cutting a ledge 12 ft. wide around a hard conglomerate perpendicular cliff. This cutting has a length of 500 ft., and was made wide enough ultimately to accommodate the wooden pipe, which follows much the same track as the tram-road. This high-level route was practically completed by January, 1914, and work was then started at many points simultaneously.

To tap the storage water in the lake two methods were available. One was to build a dam of the necessary height on the top of the natural rock bar and so raise the height of the lake; the other was to cut through this bar to the depth required to tap the water under sufficient pressure and to utilise the natural storage of the lake. The second method was adopted on the score both of expedition and cost, and also with a view to possible increase of storage capacity by raising the lake level

THE LAKE MARGARET HYDRO-ELECTRIC POWER WORKS; POWER LINES.

(For Description, see Page 3.)

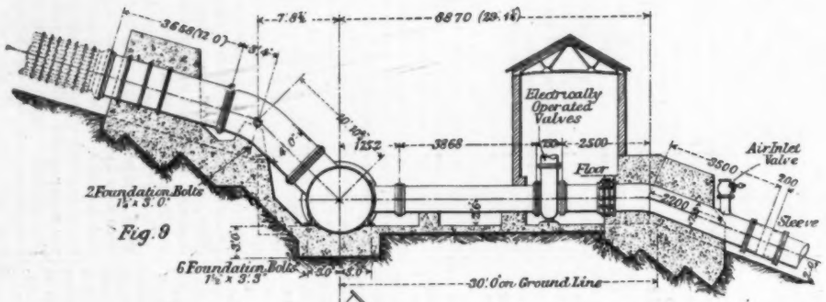


Fig. 9

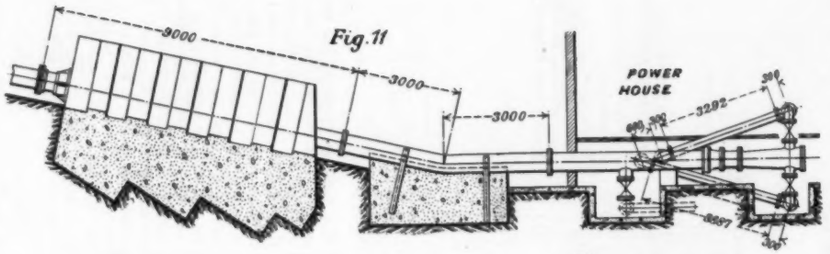


Fig. 11

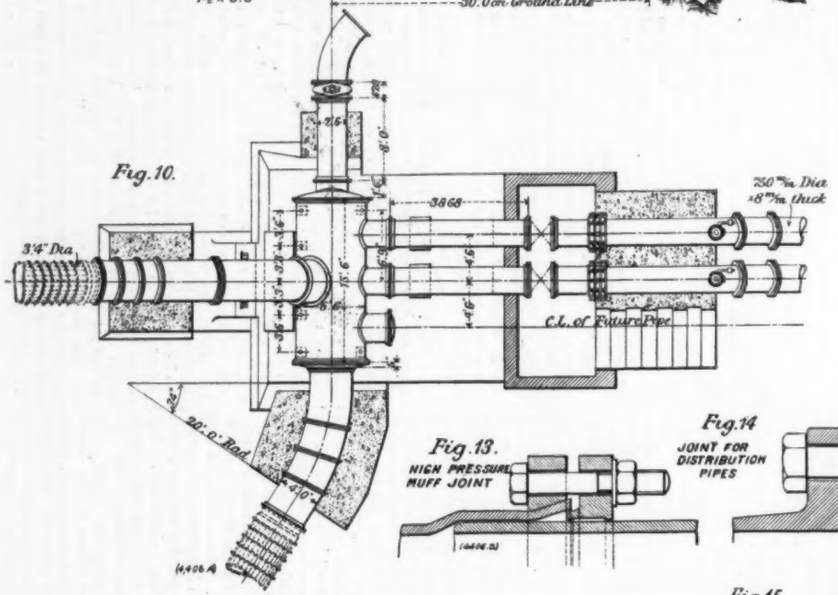


Fig. 10.

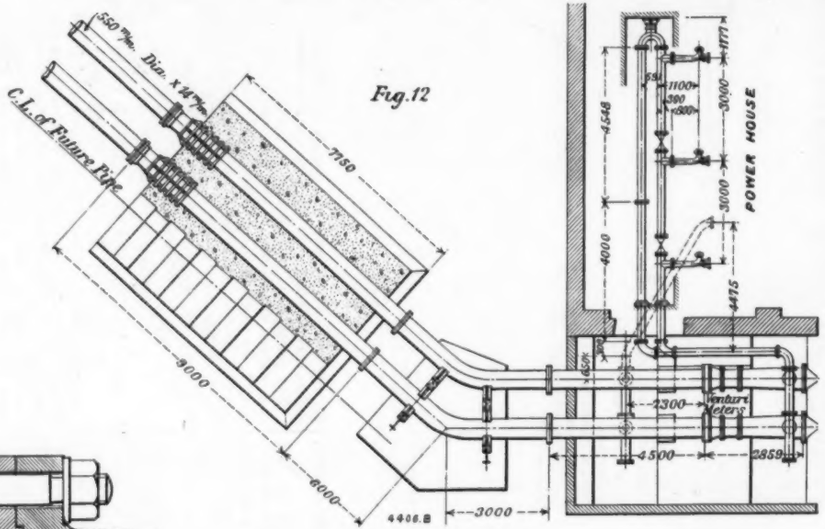


Fig. 12

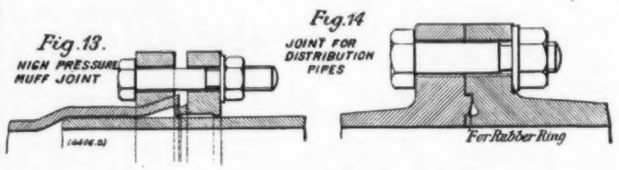


Fig. 13. HIGH PRESSURE MUFF JOINT

Fig. 14 JOINT FOR DISTRIBUTION PIPES

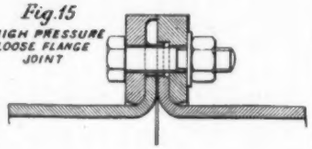


Fig. 15 HIGH PRESSURE LOOSE FLANGE JOINT

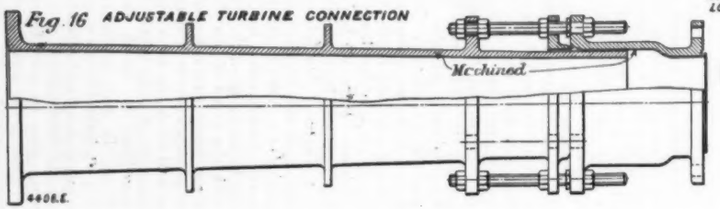


Fig. 16 ADJUSTABLE TURBINE CONNECTION

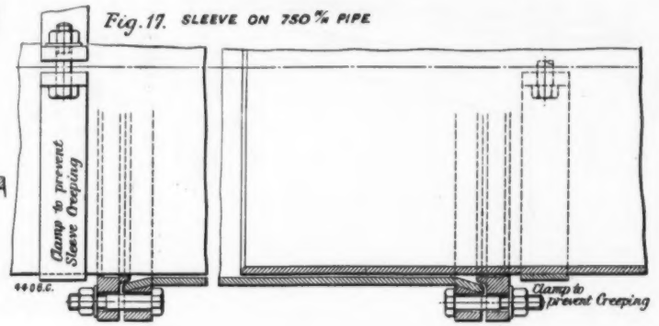
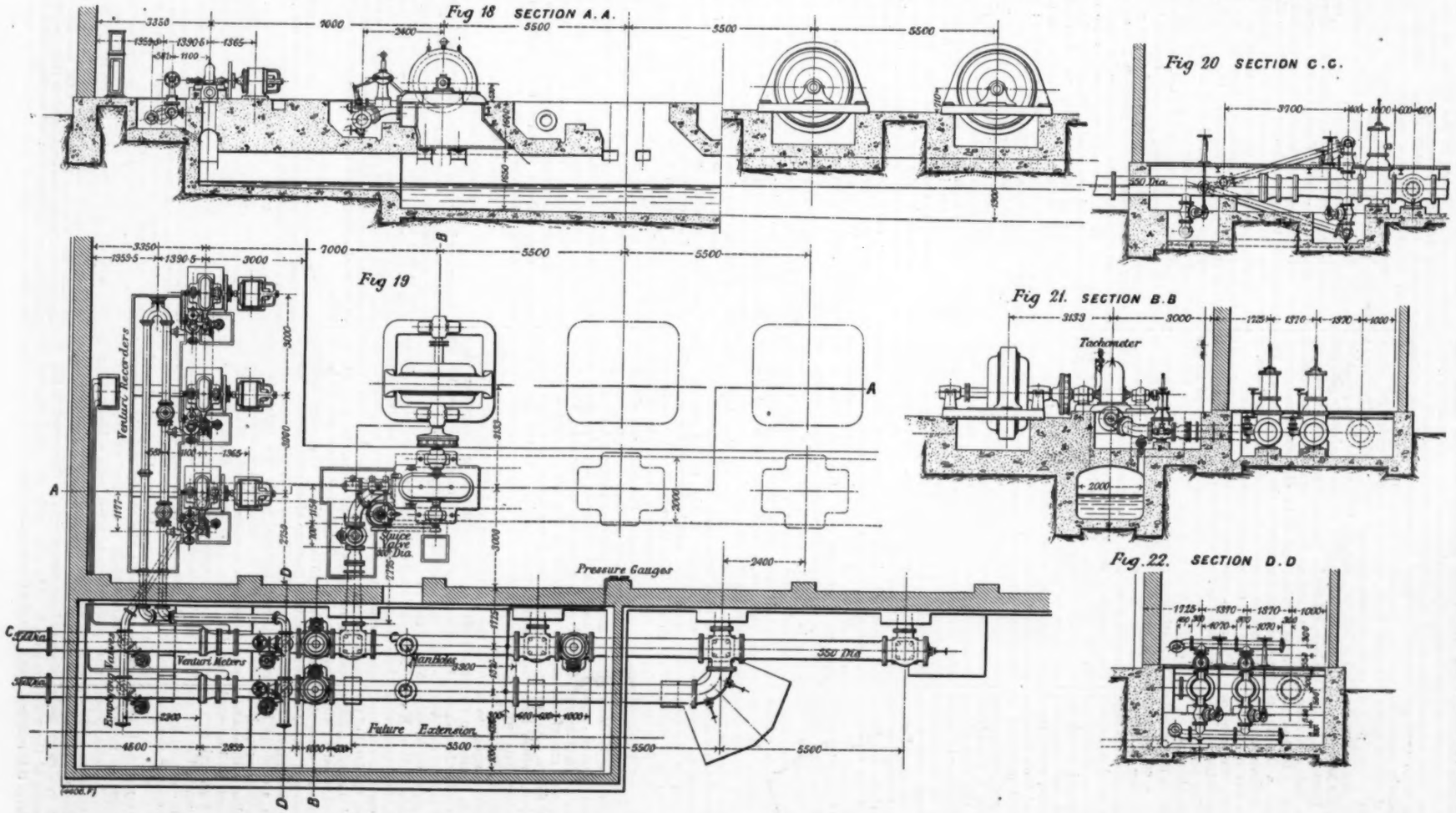


Fig. 17. SLEEVE ON 750 m/m PIPE

THE LAKE MARGARET HYDRO-ELECTRIC POWER WORKS; PIPE WORK IN POWER-HOUSE.



in the future. A cutting was accordingly put through the rock-bar, and carried back to the lake. The channel followed the natural channel already worn in the rock by the principal outlet stream, which flowed close to the precipitous walls of Mount Sedgwick. Two views of this stream are given in Figs. 3 and 4, on Plate I. The material behind the rock-bar was of a loose alluvial type, and a channel was carried through it by sluicing operations. The completion of the rock cut was carried out in the dry, and to enable this to be done the second overflow from the lake, which was in sandy formation, was deepened, and the lake was allowed to run dry. A view showing part of the cutting at this stage is given in Fig. 5, on Plate I. When the cutting was completed, it was closed by means of a concrete wall, into which two 4-ft. cast-iron outlet pipes were built. Fig. 6, on Plate I., shows this wall at an early stage. The wall was commenced in October, 1914, and finally completed in December of the same year, after the power was in use. The by-wash on the other side of the rock-bar was closed by an earth dam provided with an overflow weir. The net depth of storage secured between the by-wash level and the outlet pipes is 16 ft. This depth, compounded with the lake area, represents the present storage capacity, but this can be increased by raising the water level of the lake. The storage required to carry over the driest period on record is only 7 ft. with the present maximum discharge of 45 cub. ft. per second.

The wall is of very small dimensions, and is hardly a dam in the usual sense of the word, although it is a dam in effect. It has been made thick enough at the base to allow of it being considerably increased in height in the future if desired. The highest point of the natural rock bar is 20 ft. above lake-level, and it could, of course, be artificially heightened if required, so that an important increase in the storage is possible in the future. The two cast-iron outlet pipes which are set in the concrete wall terminate on the up-stream side in screen compartments, each pipe being fitted with a double screen of woven-wire mesh, to prevent débris and fish from getting into the pipes. The screens can be raised separately for cleaning. Between the lake and the screens flat sluice-gates are provided, which, when closed, allow of access to the screen-chambers. On the down-stream side of each pipe, just outside the dam, there is a 4-ft. sluice-valve, which can be operated either directly by hand or by means of an electric motor controlled from the power-station switchboard two miles away and fitted with limit-switches. Below these valves a cast-iron cross-connection is fitted which allows

of either outlet being used. Ultimately two wood-stave pipes will be provided, but at present only one has been built. The existing pipe connects on to this cross-connection, and it is so arranged that the future pipe may be similarly connected up when desired. Excepting for the sluice-valves, the whole of the material employed in this part of the work, such as the cast-iron pipes, screens, sluice-gates, &c., was prepared in the Mount Lyell Company's shops at Queenstown, Tasmania.

The wood pipe was built by the Australian Wood-Pipe Company, of Sydney. It has an internal diameter of 48 in. and a length of 7150 ft. As we have already indicated, it is carried along the hill-side to the top end of the pressure-pipes. It closely follows the contour of the hill, and its course is very tortuous. The minimum radius used is 150 ft. The pipe has no vertical curves, however, and descends 50 ft. on a steady grade. Wooden-stave pipes, as is generally known, have been employed to a considerable extent in America. In out-of-the-way situations, such as that at Mount Lyell, they are much more cheaply and readily installed than metal pipes, and have a long life. The pipe is built up of staves of variable length, thirty being disposed round the circumference. The end joints are staggered relatively to each other. The staves, which are of well-seasoned Douglas fir imported from America, are $1\frac{3}{4}$ in. thick by 6 in. wide, and machined all over. The side joints are V-grooved, and the end joints are butted with, in each case, a sherardised steel tongue driven into slots in the ends of two meeting staves. The pipe is held together by means of round steel bands screwing up on cast-iron shoes. The bands are of various sizes — viz., $\frac{5}{8}$ in., $\frac{3}{4}$ in., and $\frac{7}{8}$ in.—and are so spaced as to give an even factor of safety throughout the pipe. They are placed quite close together—never more than 6 in. apart—and are capable of being tightened or loosened by means of screw ends. The bands were dipped in boiling tar before being put in place. A view of the pipe during construction is given in Fig. 23, on page 8. The strength of the pipe is furnished by the steel bands. The staves are purposely kept thin, as heavy thicknesses would probably lead to decay. It is expected that the wood will permit the transpiration of a small amount of water and thus keep the fibres in a healthy state. The pipe is not fastened down, but simply lies on bearers or trestles on the ground.

At its lower end, where it connects to the pressure-pipes, the wood pipe terminates in a riveted steel-plate header, which is illustrated in Figs. 9 and 10, on page 4. The header is cylindrical, 6 ft. 6 in. in diameter and 15 ft. 6 in. long. It is provided with three $29\frac{3}{4}$-in. branches on its lower side for the connection of the steel pressure-pipes which lead to the power-station. Two pressure-pipes only are at present fitted, and one of the branches is closed with a blank flange. At one end of the header there is a $29\frac{3}{4}$-in. branch leading, through a valve, to a scour-pipe which discharges into the valley below, while in the middle there is a 48-in. branch leading to a stand-pipe which runs about 150 ft. further up the hill, and terminates at an altitude a few feet above lake-level. This stand-pipe is of wood of the same construction as the main supply pipe, but in order to serve as a test it has been made of local King William pine. It acts as a vent and nullifies the effect on the pipe-line of large variations in load. If a heavy load suddenly comes on, the level of the water in the stand-pipe falls until the main column of water attains the newly required velocity; while if a heavy load is suddenly thrown off, water discharges from the top of the stand-pipe and takes the back pressure shock off the main pipe. The cylindrical header is anchored on a concrete base and is relieved from any strain from the pipe-lines or stand-pipe, as these are supplied with separate main anchorages. The arrangement is illustrated in Figs. 9 and 10, page 4, while a general view of the same part of the work is given in Fig. 24, on page 8. In this case the header is obscured by the temporary cable-way which has been laid alongside the pipes.

The two steel pipe-lines are 2909 ft. in length. As already mentioned, arrangements are made for fitting a third pipe in the future. The present pipes feed four 1750-brake-horse-power turbines, together with the necessary exciter turbines. The third pipe, when fitted, will allow of two more main turbines being installed, the capacity of the wood pipe-line being sufficient to deal with this increase.

The steel pipes, together with the header, distributing-pipes, valves, and the valves at the top of the wood pipes, to which we have already referred, were all designed and supplied by Messrs. Boving and Co., Limited, of Union-court, Old Broad-street, London, E.C., and were erected under the supervision of their engineer. The 2909-ft. pipes have a fall of 1040 ft., and the total static head available, including that supplied by the wood-stave pipe and the lake, is 1100 ft. The pipes are in lengths of about 19 ft. 6 in., and are divided into three equal sections of 30 in., 26 in., and 22 in. diameter respectively, decreasing in size towards the power-station. The thickness increases by 1 mm. stages, from 8 mm. at the top to 14 mm. at the power-station end.

The pipes were manufactured from open-hearth steel plates having a tensile strength of 23 to 27 tons per sq. in., and a minimum elongation of 25 per cent on an 8-in. specimen. The joints are welded. The method of procedure was to roll the plates to shape with an overlap at the joints, and then to weld by heating with water-gas. Pneumatic hammers were used in a special welding-machine. The strength of the weld is from 90 to 95 per cent. that of the plate. After welding the pipes were cut square at the ends in a lathe, the joint rolled, and were annealed in gas furnaces. The pipes were then scraped with steel brushes, and while hot were given three coats of coal-tar pitch and oil. The factor of safety of the completed pipes is 4.95, allowing for a 90 per cent. strength in the weld. They were tested hydraulically to $1\frac{1}{2}$ times the working pressure before leaving the factory. Manholes for inspection are provided at intervals in the completed pipes. At each bend the pipe-lines are embedded in concrete anchorages, in which are a number of cast-iron split-rings. The thrust is transmitted to these rings by angle-iron rings riveted to the pipes. On long straight sections intermediate anchorages of the same type are used, but carrying only halfway up the pipe diameters. Each pipe rests on a concrete pier. General views of the pipe-line at different stages of construction are given in Figs. 7 and 8, on Plate I., while the upper and lower ends are shown in Figs. 9 and 10, and Figs. 11 and 12, on page 4. A further view of the pipe-line, looking from the top of the hill, is given in Fig. 25, on page 8.

The main-pipe joints are of the single high-pressure muff type with solid rolled-steel loose rings, as illustrated in Fig. 13, on page 4. The joints are packed with impregnated rope packing. This class of joint is very flexible; each pipe is free to expand separately, and slight subsidences do not cause leakage. The joint can also be repacked from outside without disturbing the pipes. Below each fixed point, or anchorage, a long sleeve-pipe is used which allows of any pipe being withdrawn from between two anchorages. The sleeve-pipe is illustrated in Fig. 17, on page 4. It will be seen that the joints are of the same type as those used on the main pipe. At the top of each pipe-line there is a 30-in. motor-operated sluice-valve with a by-pass. These valves are controlled from the power-house switchboard, and are fitted with limit-switches which shut off the motors when the valves are opened or closed. The valves are housed in a small building which is shown in Figs. 9 and 10.

At their lower ends the two steel pipes change their direction, and connect on to two distributing-pipes, which run parallel with the long wall of the power-house, and on the level, as shown in Figs. 11 and 12, on page 4, and Figs. 18 and 19, on page 5. These distributing-pipes are 22 in. in diameter and 15 mm. thick. They were tested to twice working pressure after manufacture. As will be seen from Fig. 19, the inner pipe extends to the most distant turbine, while the outer is only carried as far as the third, and is connected to the inner pipe by a cast-steel bend. We should say that four main turbines are fitted, although, in order to save space, only three are indicated in Fig. 19. The bend at the end of the outer pipe is arranged to take an end thrust, by being formed with chocks which bear against vertical joists set in a concrete anchor block. Large steel wedges are fitted between the chocks and the joists. A similar thrust-block is arranged at the end of the inner pipe, which is fitted with a blank flange to allow of extensions in the future. The joints used throughout the distributing-pipes are of the high-pressure loose-flange type, as illustrated in Fig. 15, on page 4. The pipe ends are rolled up, and the joint is a double-insertion ring.

The various branches and fittings on the distribution-pipes are shown in the figures on page 5. Beginning from the in-coming end, there are first two 10-in. hand-operated scour, or emptying, valves fitted to branches on the bottom of the pipes, and discharging by a common pipe direct into the Yolande River. These connections allow of the main pipes being periodically cleaned of sediment and foreign material, and of either columns being emptied for examination. Next in order there comes the Venturi-meter ring-chambers and throat-pipes, which are connected to recorders in the power-house. After these there come four 10-in. hand-operated sluice-valves for the distribution-pipes to the exciter turbines. The valves are fitted on branches on both the top and bottom of the pipes, as shown in Figs. 19 and 22, and discharge to a 10-in. U-pipe circuit which is anchored to the power-house wall. The U-pipe is fitted with two hand-operated valves, as shown in Fig. 19. The arrangement gives alternative routes of supply to all the exciter sets, and allows of the running of more than one of them in the case of shut-down of part of the pipe system for repair.

The main 22-in. hydraulic sluice-valves are electrically and hand operated. There are three of them, disposed as shown in Fig. 19. The valves are fitted with by-passes for equalising the pressure on either side of them before opening; they are closed and opened by the main water pressure, which is admitted over or under a piston, which works in a cylinder above the valve. The piston movements are controlled by hand or by an electric motor, operated from the main switchboard. The branches to the turbines are taken off from cast-steel T pieces, as shown, one of the pieces—that for C turbine—having an extra branch for connection to the outer distributing-pipe. Connection is made to each turbine through an adjustable sleeve-pipe, one of which is illustrated in Fig. 16, on page 4. The type of joint used in connection with this pipe is illustrated in Fig. 14, on the same page.

The Venturi-meter installation, which may be looked upon as part of the pipe system, consists of the throats and ring-chambers, to which we have already referred, and two recorders mounted in a case in the power-house. The small part of each throat has half the area of the full-bore pipe. The full-load friction loss is equivalent to 2 ft. of head. The recorders, which are connected to the Venturi throats by $\frac{3}{8}$-in. copper pipe, are of the combined counter and diagram type, giving the rate of discharge in gallons per minute on daily diagrams, and at the same time recording the total discharge on the counters. The drums of the recorders are clock-driven. Above each flow diagram there is a pressure diagram, which enables pressure variations to be read synchronously with the fluctuations in discharge. There are also two 10 in. in diameter hydraulic pressure-gauges mounted on the station wall. These indicate the pressures in pounds in the main pipes.

(To be continued.)

DEARTH OF RUBBER IN SWEDEN.—The rubber famine in Sweden has now become so pronounced that all the rubber factories, save the one at Helsingborg, simply have to stop work. The Malmö factory had to discontinue work some weeks ago, and the one at Trelleborg, which employs some 400 hands, has now had to do likewise. The factory at Helsingborg succeeded in securing a sufficient stock of rubber in time, and work there goes on as usual, although all demands cannot be complied with.

OUR RAIL EXPORTS.—The value of the exports of rails from the United Kingdom during the ten years ending with 1914 inclusive was as follows:—

Year.	Value.	Year.	Value.
	£		£
1905	2,731,854	1910	2,825,504
1906	2,591,363	1911	2,300,992
1907	2,700,096	1912	2,537,654
1908	2,769,344	1913	3,622,342
1909	3,357,010	1914	3,020,900

Rails have hardened in price during the last ten years, but the rise has been less marked than might have been rather anticipated in view of the great advance which has taken place in the remuneration of labour. The average price in 1905 was 5*l.* per ton; in 1906 the average rose to 5.63*l.* per ton; and in 1907 to 6.54*l.* per ton. In 1908, however, there was a fall to 6.12*l.* per ton, and in 1909 a further decline was witnessed to 5.79*l.* per ton. In 1910 an average of 5.86*l.* per ton was recorded, in 1911 of 6.13*l.* per ton, and in 1912 of 6.13*l.* per ton. An appreciable advance was established in 1913, the average coming out at 7.13*l.* per ton; but in 1914 it fell to 6.84*l.* per ton.

INDUSTRIAL NOTES.

ON Friday, December 31, the Prime Minister and the Minister of Munitions received a deputation of the Amalgamated Society of Engineers, who attended to lay before them certain points in regard to the dilution of labour in connection with the Munitions Amendment Bill. The deputation was introduced by Mr. J. T. Brownlie, chairman of the executive council of the society; and the Prime Minister and Minister of Munitions were accompanied by Dr. Addison, M.P., Sir H. Llewellyn Smith, Mr. W. H. Beveridge and Mr. Isaac Mitchell.

In the course of the proceedings the Prime Minister spoke as follows:—

The important thing from the point of view of the State is that this dilution of labour should take place. It is all important. Mr. Lloyd George cannot carry on his work efficiently and meet the necessities of the war unless dilution is resorted to; nor, consequently, can the Army until this dilution of labour is resorted to on a large scale, and unless it is applied whole-heartedly. It must be applied whole-heartedly and with the full consent and, not only the co-operation, but more than the co-operation of societies like yours. It is all-important that we should get the output we require. It is important from another point of view, and that is that the output should, as far as possible, be domestic, and not foreign, because the financial problem in front of us—and a very serious one—is the obligation to pay, which can only be done in the shape of exports or gold to pay to America and countries like that for the munitions which we are getting from there. It is important from both those points of view, and it is an enormous gain from the point of view both of military efficiency and financial stability. It is an incalculable gain. But in spite of the agreement made last March, unfortunately this process of dilution has been most sparingly adopted. No doubt it is a very difficult thing to persuade men who regard what I may call the priorities and privileges of skilled labour as almost gospel, to forego for the time being those privileges, and admit unskilled and semi-skilled men into a class of work which skilled men have been in the habit of doing. They have a fear—one which is perhaps not altogether unnatural—that when the war comes to an end the re-establishment of the old conditions will be impossible, and that all these elaborate safeguards, which have been built up by generation after generation of trade unions for the protection of their members, will be found to be undermined. I think that is really what is at the bottom of it; is it not?

Mr. Brownlie: Yes.

The Prime Minister: I suspect that is the feeling, and I agree it is one which is difficult to eradicate in a moment, or even in a month. The only way by which the new arrangement can be successfully dealt with is by the unions exerting all their force to remove these suspicions and to encourage the men, and, indeed, as far as they can, I will not say coerce, but bring every influence they can to bear upon them under the stress of this great national necessity to consent to this temporary process, which is absolutely necessary for the proper conduct of the war. I do not think you differ from me in anything I have said so far. I believe you feel it as strongly as we do, and that it is your duty just as much as it is ours.

To come back to the Circular L 3, as I gather, if it were observed and carried out by the employers you would agree that the process of dilution had been properly safeguarded, and that the interests which you represent were not compromised by the substitution, to whatever extent it has to take place under the so-called process of diluting skilled labour with semi-skilled or unskilled labour. What I understand you to ask is that in this Amending Bill the Ministry of Munitions should be given statutory powers to enforce the provisions of the same in controlled establishments.

That power has already been taken in regard to women, who fall within the ambit of Circular L2. But what you want is that the Minister should have those powers in regard to semi-skilled and unskilled men. I should be disposed myself to acquiesce in an amendment carefully framed on those lines, provided that I could get from you an assurance on behalf of your society that this will settle the whole matter. By "settling the whole matter" I mean to put an end once and for all to this long series of, I will not say complaints—I do not want to use any language that seems to suggest unreasonableness—but of demands and grievances, which, up to this time, as you must all agree, have hindered the carrying out of the agreement of last March. It has not been effectively carried out. As regards large parts of the country, it has not been carried out at all. Nine months have elapsed, and this is a matter of absolutely vital necessity. I am speaking for myself and of the impression that has been made upon my mind by our conference together. I feel disposed to suggest to the Minister of Munitions that he might make you this concession, provided he can get from you, not as a matter of bargain (we are not here haggling in the market as to the price or quality of goods) an assurance that we have come to an end of all these troubles.

At the end of the proceedings the deputation came to the following conclusion:—

"That we, representing the A.S.E. National Conference, having heard the statements and pledges of the Prime Minister and the Minister of Munitions, decide to accept on behalf of the Conference and membership of the Society the scheme of dilution and to co-operate actively therein, provided that the Government pledge itself to incorporate in the Bill the power to enforce the rates of pay and conditions of labour, as set out in documents L3 as well as L2 in controlled establishments."

The Bill amending the Munitions of War Act, 1915, with this and other concessions to workers, was passed in the House of Commons on Tuesday, when Mr. Lloyd George made another appeal to workers to play their part in the war in giving unstintedly of their energy to maintain all supplies and munitions to the fighting army.

The following figures are taken from the interesting annual report on the year 1915, which was issued on the 3rd inst. by the *Manchester Guardian*:—

The upward movement in wages began early in 1915 in the munitions and transport industries; from March onwards "it spread to nearly all the principal industries, and its effects have been far greater than that of any other upward movement in wages previously recorded." The Board of Trade estimates, in fact, that whereas in the first seven months of 1914 the decline in wages which had begun in 1913 produced a net decrease in wages of nearly 13,000*l.* a week, in the first year of war there was an increase of about 750,000*l.* per week in the wages of 4½ million workpeople. The table, which includes only the manual-labour class (not shop assistants, clerks, salaried officials, or domestic servants), shows particulars of these increases in bonuses and advances in wage rates in the first year of war:—

Groups of Trades.	Estimated Number of Work-People Affected.	Estimated Weekly Increase in Rates of Wages. £
Trades in which the estimated numbers affected are reported to the Department:—		
Building trades	110,000	11,000
Coal-mining	870,000	223,000
Other mining and quarrying	32,000	6,700
Pig-iron and iron and steel manufacture	123,000	23,000
Engineering and shipbuilding	624,000	108,400
Other metal trades	79,000	11,300
Textile trades	414,000	33,000
Clothing trades	91,000	8,300
Transport trades	142,000	28,400
Printing and paper trades	22,000	2,100
Glass, brick, chemical, pottery, &c., trades	102,000	9,700
Employees of local authorities	96,000	9,600
Other trades	141,000	19,300
Total of above	2,846,000	493,800
Trades in which the numbers affected are estimated by the Department:—		
Railway servants, seamen, agricultural labourers, police, and Government employees	1,600,000	270,000
Grand total	4,446,000	763,800

As the table shows, the bonuses granted in the principal coalfields in May and the subsequent wage increases in South Wales and Scotland constitute the largest item in the total gain. In the engineering trades skilled men have gained 3s. or 4s. a week, and in the principal shipyards a similar rise has been secured. In the transport trades dock labourers at most important centres had increases of 1d. per hour, and carters advances of between 1s. and 4s. per week. Government employees in His Majesty's dockyards have received advances of 1s. to 5s. per week; male postal servants under 60s. per week have received 2s. or 3s. per week, females 1s. or 1s. 6d. In February railway servants received a bonus of 2s. or 3s. a week; in October a further addition (not included in the table) raised this to a uniform 5s. per employee over eighteen.

The figures in the table show that some three million workpeople had in the first year of war received increases averaging 3s. 6d. per head in money wages. The average increase by the end of the year may very probably be higher than this; in some cases it undoubtedly is very much higher. But while it is true that the war has produced a great and general rise in the wages of those employed on the necessaries of war, we must not fall into the error of talking of money wages as if they were identical with real wages. It is questionable whether the average rise in money wages (apart from the increases earned by overtime) has much more than covered the rise in prices. Nor must the fatigue and strain attendant on overtime, Sunday work, &c., be left out of account. A memorandum just issued by the Health of Munition Workers' Committee shows the evil effects of excessive and unbroken work, which is recognised to be uneconomical.

An interesting article was given in *The Times* of Saturday, the 1st inst., under the heading, "A Land of One Idea." It states that the people of France realise that they are at war. The increase in the production of munitions is due to one cause and one only, and that is, the patriotic enthusiasm which exists there. No trade-union restrictions exist at the moment. These sentences, adds the journal, give the keynote to a report of exceptional interest which has been drawn up by the British Mission recently appointed by Lord Murray of Elibank to inquire into labour conditions in the munition factories of France, where, although one-eighth of the land and five-eighths of the former metallurgical productivity are now in enemy hands, an enormous increase in the output of war material has taken place.

The mission consisted of Mr. J. T. Brownlie, chairman of the Amalgamated Society of Engineers; Mr. A. Duckham, Ministry of Munitions; Mr. D. J. Shackleton, Labour Adviser to the Ministry; and Mr. Allan M. Smith, Secretary of the Engineering Employers' Federation. To the party were attached two experienced munition engineers. Twenty-three establishments in various industrial districts were visited. The greatly-improved output was found to be due to three causes:—

1. Increased intensity of production.
2. Erection and equipment of new factories, and extension of existing munition factories.
3. Adaptation of existing factories to the manufacture of munitions.

The dominant sentiment, not only of the men but also of the women, was to carry the war to a successful end; everything else was subordinated to this determination. There was no restriction in the work which a woman may do. The introduction of unskilled male and female labour had not presented the difficulties experienced in this country. It was ascertained from representatives of the trade-union movement in France that trade-union conditions in regard to wages and labour had been practically suspended. A remarkable feature in the French factories was the almost entire absence of lost time. A large proportion of the male labour employed was military. Although before the war the usual labour troubles were experienced, no strike had taken place since the commencement of hostilities. No applications for general advances in wages had been made by the workpeople since the war began.

The Minister of Munitions announces that he has made an Order under Section 4 of the Munitions of War Act, 1915, declaring 396 additional establishments as controlled establishments under the Act, as from January 1, 1916. A total of 2422 establishments have now been declared as controlled under the Act, from the date of the first Order, July 12, 1915, to January 1, 1916, inclusive.

THE EXPORT OF SWEDISH IRON ORE DURING 1916.—The Kirunavara-Luossavara Company had calculated an export of Lapland iron ore for 1916 amounting to an aggregate of 5,050,000 tons, of which quantity 3,300,000 tons were to come from Kirunavara. As the war, however, bids fair to continue during 1916, and some considerable time is likely to elapse after the conclusion of peace before marine transport becomes anything like normal, the company is of opinion that the ore export during 1916 will have to be materially reduced. Under these circumstances a much smaller quantity must be reckoned upon, viz., 2,000,000 tons from Kirunavara and 500,000 tons from Gellivara. For the following year, 1917, the company has estimated the export at a total of 5,350,000 tons, 4,150,000 tons from Kirunavara and 1,200,000 tons from Gellivara.

THE BRITISH FIRE-PREVENTION COMMITTEE.—The following are some particulars of the war emergency work conducted by the British Fire-Prevention Committee. The Committee's warnings service embraces the preparation and free issue of a large number of public "Fire Warnings" in connection with the war emergency, disseminated by the Committee in the form of posters, circular letters, or notices. At the outbreak of the war, the Committee formed a special fire survey force of 100 surveyors to undertake at short notice, in an honorary capacity, any fire surveys required by the Government. Many establishments taken over for the war emergency were surveyed by this force, including numerous hospitals. The whole of the complex technical work arising out of the above services has been carried out gratuitously by a sub-committee, loyally assisted by the clerical staff of the British Fire-Prevention Committee, and in its operations the Committee invariably kept in close touch with the public departments concerned. The results of the work have been far reaching. The greater care taken by the public to prevent outbreaks of fire by sensible and inexpensive precautionary measures has been most marked, as also the effort to meet fires with organised self-help and simple hand-fire appliances. A material reduction of the annual fire loss during the war has been achieved. The loss of life from fire has been reduced and large quantities of produce and goods important to the conduct of the war have been thereby preserved.

YEAR-BOOKS AND ANNUALS.

The British Engineers' Association.—We have received from this association, whose offices are at 32, Victoria-street, Westminster, London, S.W., a copy of the Russian edition of their official directory. It forms the first step in a campaign carried on by the association on behalf of British engineering firms for the capture of Russian trade after the war. The association represents only *bond-fide* British engineering firms, British contractors, and owners of proprietary rights in goods manufactured in Great Britain. The book gives the names of the Members of Council of the association, and a directory, arranged alphabetically under trades and products, in English, with Russian translations, of British manufacturers of all classes of goods. It is sure to prove a great help in the development of business intercourse with our great Eastern Ally.

The Potsdam Diary.—There is a page in this diary for every day in the year, and on each page there is an extract from a speech by some politician dealing with the relations of England and Germany or with politics in general. These extracts do not make pleasant reading, for they show how entirely our politicians misread the signs of the times. However, the total aggregation does not make a more pitiable record than Mr. Lloyd George's "Too late" speech of a fortnight ago. The diary is compiled by Mr. L. T. Maxse, and is sold at the *National Review* Office, price 1s. 6d. net.

Diaries.—Messrs. Henry Simon, Limited, of 20, Mount-street, Manchester, send us their usual tear-off diary. They have issued this annually for many years, and they enrich each page with some aphorism or verse full of wisdom. The first we opened upon was the Chinese proverb, "Learning without thought is labour lost; thought without learning is perilous." This would make an excellent motto to inscribe over the portals of our colleges. Another, "The ultimate result of shielding men from the effects of folly is to fill the world with fools," might be commended to the consideration of our legislators.—Messrs. Cammell Laird and Co., Limited, issue a very serviceable diary, with conversion tables, a commendable feature being the inclusion of detachable section-marked pages in the centre of the diary.

Almanacks and Calendars.—We have received from Messrs. John I. Thornycroft and Co., Limited, a very neat almanack illustrating H.M.S. Lance, the first British war vessel to score a success in the great war; she was built by Messrs. Thornycroft in 1914. Other almanacks come to hand from Messrs. Geo. Cradock and Co., Limited, Wire Rope Works, Wakefield; from Messrs. Dickson and Mann, Bathville Steel Works, Armadale, and 7, East India-avenue, London, E.C.; Messrs. George Fletcher and Co., Limited, Colliery, Mining, and Cement Works Plant, Derby; Messrs. Peckett and Sons, Limited, Locomotive Builders, Bristol; the Consolidated Pneumatic Tool Company, Limited, Palace Chambers, 9, Bridge-street, Westminster, London, S.W.; Messrs. John Rogerson and Co., Limited, Wolsingham, S.O. (Durham); the British Thomson-Houston Company, Limited, Rugby. We have also received a refil from the Welin Davit and Engineering Company, Limited, 5, Lloyd's-avenue, London, E.C., and from Messrs. Richard Garrett and Sons, Limited, Leiston Works, Leiston. We have further received a daily tear-off calendar from Messrs. E. G. Wrigley and Co., Limited, manufacturers of twist-drills and milling-cutters, Foundry Lane Works, Birmingham; an almanack from Messrs. John Smith and Co., Grove Works, Carshalton, Surrey; a monthly tear-off calendar from Messrs. Charles Churchill and Co., Limited, machine-tool manufacturers, 9 to 15, Leonard-street, London, E.C.; one from Messrs. Cammell Laird and Co., Limited, giving a view of their large-calibre-shell machining-shop; a daily tear-off calendar from the Davenport Engineering Company, Bradford; a celluloid pocket-book almanack, combined with fractional inch measurements, from Messrs. Robert Boyle and Son, ventilating engineers, London and Glasgow. The Langdon-Davies Motor Company, Eastdown Works, Demody-road, Lewisham, and 110, Cannon-street, E.C., have sent us a pocket-book containing tables and information on some of their standard sizes and types of motors. The United States Metallic Packing Company, Limited, Soho Works, Bradford, Yorks, have issued an artistic monthly tear-off almanack; and Messrs. Urquhart, Lindsay and Co., Limited, Blackness Foundry, Dundee, a very neat calendar. A very clear monthly tear-off calendar comes from Messrs. William Clowes and Sons, Limited, Duke-street, Stamford-street, London, S.E., specialists in all classes of foreign printing; also one from Messrs. Alfred Herbert, Limited, Coventry, giving views of their factories and specialities; one from the Ironite Company, Limited, 11, Old Queen-street, Westminster, S.W.; and a desk almanack from Messrs. B. and S. Massey, Limited, Openshaw, Manchester.

LAKE MARGARET HYDRO-ELECTRIC POWER WORKS.

(*For Description, see Page* 3.)

FIG. 23. WOOD PIPE-LINE UNDER CONSTRUCTION.

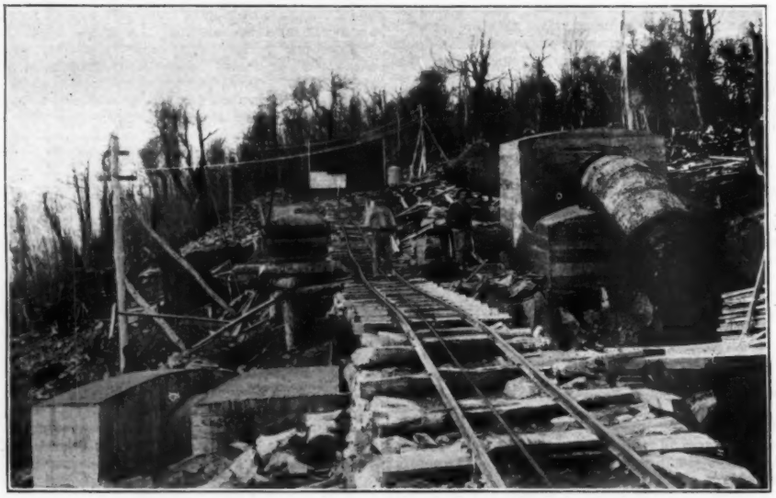
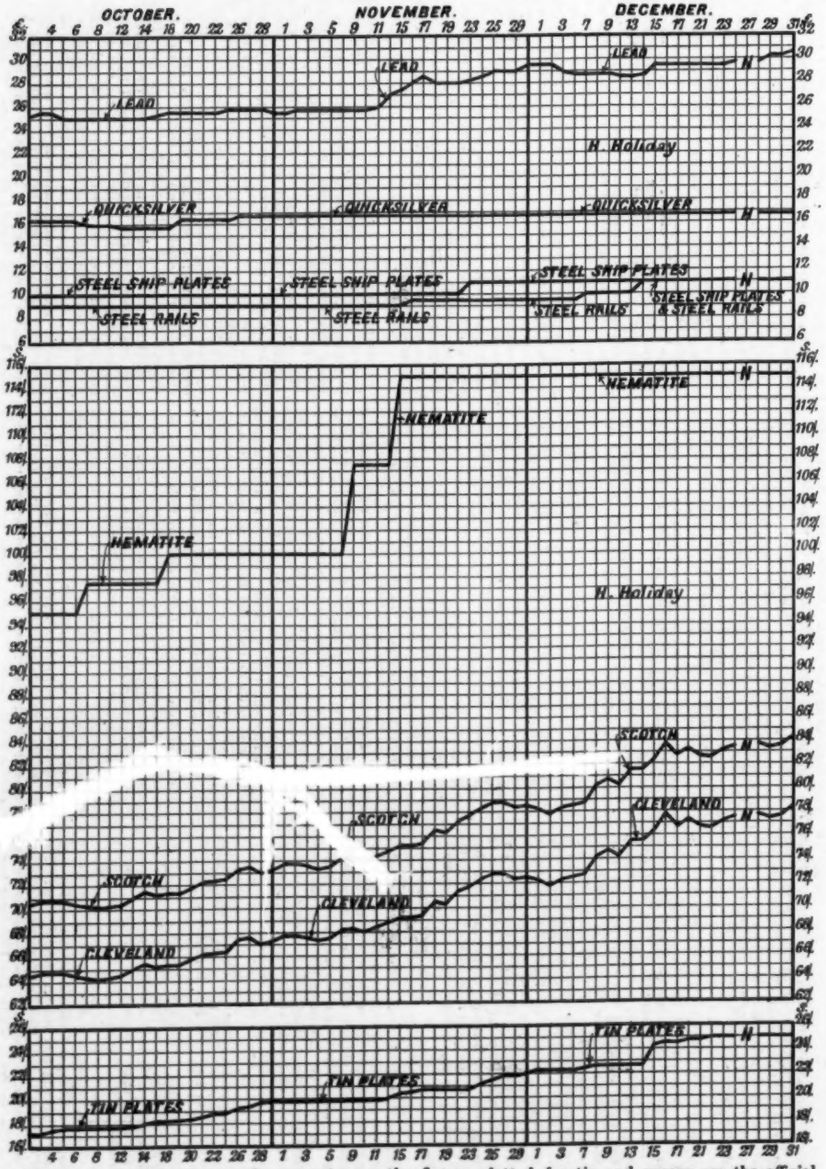


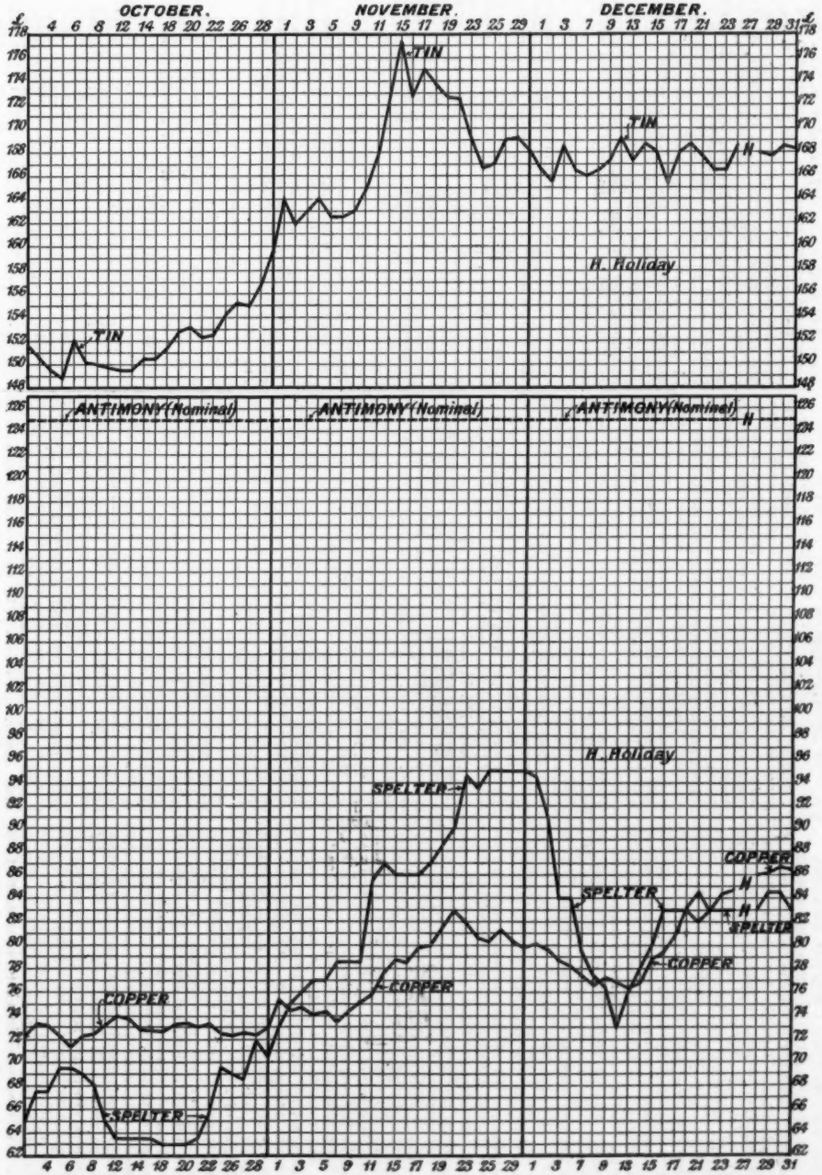
FIG. 24. JUNCTION BETWEEN WOOD AND STEEL PIPE LINES.

FIG. 25. STEEL PIPE LINE, LOOKING FROM TOP OF HILL.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.



NOTE.—In the diagrams on the present page the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for "fine foreign" and "standard" metal respectively. The prices plotted for antimony and lead are for English metal in both cases, while those for spelter are for American metal—the only kind at present available. Steel ship-plates and heavy steel rails are plotted to Middlesbrough quotations; the usual discounts are allowed in the case of ship-plates, but rails are net, free on board, at Middlesbrough. The figures plotted for hematite, Scotch and Cleveland irons are Glasgow settlement prices, and these prices are per ton, as are



also those for all other metals previously mentioned. The price of quicksilver is, however, per bottle, the contents of which weigh about 80 lb., and the price of tin plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market day, and the horizontal lines represent 1*l.* each in all cases, except those of hematite, Scotch and Cleveland irons and tin plates, where they represent 1*s.* each.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, December 22.

THE event of the week is the sharp advance in all kinds of crude iron. Bessemer has reached 20 dols.; basic and foundry, 19 dols. Capacity is largely sold up to July. New business is for late delivery. Sales of foundry for the week for domestic purposes were 100,000 tons. The week's business in structural material has been double the producing capacity. Steel for quite a number of new projects is now urgently called for, resulting in a further marking up of prices. In Eastern markets bookings for constructional material foots up 500,000 tons, with stock one-seventh of that tonnage. The Carnegie Company will start its new and elaborate blooming-mill on January 2, a marvel in the steel-making art, where blooms will be rolled direct from the ingot after it is stripped, without reheating; but if the new mill cannot handle all the ingots, facilities are provided for the reheating of the surplus. New means are also provided for handling crop-ends with less labour, for which there is an excessive demand. Steel billets have advanced 1 dol.; rerolling billets are 40 dols.; forging billets, 55 dols. The scarcity of billets is holding back many projects. Many mills are still working on low-priced contracts placed earlier in the year—viz., at 1.25 dols. to 1.40 dols. Plate-makers will now soon open their books for the late half of 1916. Shipbuilders are pushing plate mills to accept new business.

Car-builders are placing contracts for plates as far ahead as they can induce mills to accept orders. Wire mills are sold six months ahead, and material for export is being shipped to Philadelphia and Baltimore. South America is calling for large quantities of tin-plate, which is selling at very high prices, and an advance of 2 dols. to 3 dols. a ton is in sight, especially on export orders; the general tone of the market is very strong. Reports of enlarging capacity are frequent. Munition demand has subsided, although estimated requirements of all kinds run into some hundreds of thousands of tons. The steel industry is now under maximum pressure, but considerable expansion will be completed during the winter months. Domestic demands of all kinds continue to expand. Shipbuilding is especially active, and the number of large and small vessels now under construction is very large, crowding all shipbuilding capacity to the extreme limit. Higher prices will be announced from time to time, but it will be some time before the bulk of the low-priced business will be cleared off the books.

THE LATE MR. ARTHUR JOHN COTTERILL.—We regret to have to announce the sudden death, on Monday, December 27, of Mr. Arthur John Cotterill, who was at one time Engineer-in-Chief of the Egyptian State Railways. Mr. Cotterill was a son of the late Dr. Cotterill, Bishop of Edinburgh.

LEEDS CORPORATION TRAMWAYS.—New administrative offices have been installed for the Leeds Corporation tramways at the corner of Sovereign-street, Swinegate and Lower Briggate. The undertaking has been continually growing, and the capital expended now exceeds 1,000,000*l.*, the total including 200,000*l.* paid for land and buildings. There are more than thirty routes, and the daily average distance run by each tramcar is 113 miles. There are more than 200 cars in daily use, and in the course of a year 9,000,000 car-miles are run. The number of passengers carried is 90,000,000 annually. For the last ten years the surplus profits from the undertaking have averaged more than 60,000*l.* per annum. The tramways were acquired by the Leeds Corporation in 1894, and during the last twenty years 1,000,000*l.* has been earned in relief of the local rates, after provision for interest on sinking fund, permanent-way renewals, repair of cars, &c.

ARMOUR-PLATE PRICES IN THE UNITED STATES.—We read in the *Iron Age* that the bids submitted on November 17 for 16,021 tons of armour-plate and special steel give no support to the charge that the manufacturers are seeking to take advantage of the Government's necessities. In spite of the increased cost of every element of steel production, these bids are close against the prevailing level of recent contracts. They are as follow:—

—	Class A 1, 14,479 T Per Ton.	Class A 2, 880 T. Per Ton.	Class B, 602 T. Per Ton.	Class C, Special Steel, 120 T. Per Ton.
	dols.	dols.	dols.	dols.
Carnegie Steel Co...	425	455	460	—
Bethlehem Steel Co.	435	490	495	595
Midvale Steel Co. ..	436	496	496	576
Pittsburg Screw and Bolt Co.	—	—	—	484

The Carnegie Steel Company offered to take all or one-half the armour, but did not bid on special steel. The Bethlehem Company's bid was for the total amount covered by all classes. The Midvale Company bid on one-half the entire contract, while the Pittsburg Screw and Bolt Company's proposal covered all the special steel only.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Last Wednesday morning prices in the Glasgow pig-iron warrant market were rather irregular, fluctuating from 77s. 10d. cash at the opening to 77s. 5d. per ton at the close, when also one-month sellers were quoted 77s. 11d. For nine days 77s. 10d., 77s. 9d., and 77s. 7d. were quoted, and at these different figures mentioned a limited business of 1500 tons was put through. Business was brisker in the afternoon, when 5000 tons were dealt in, prices still alternating between 77s. 4d. and 77s. 5½d. cash, and 77s. 10d. and 77s. 10½d. one month. At the close, however, cash sellers were 1d. up from the morning, while for one month the price remained at the same figure. Thursday morning showed a much firmer tone, cash iron being dealt in up to 77s. 9d., with sellers over, 78s. 2d. being realised for one month's iron. Sellers' quotations at the close showed an increase of 3d. to 4d. per ton. The turnover amounted to 2500 tons. A further advance took place in the afternoon, cash iron going up to 78s. and one month's to 78s. 4½d. per ton. A restricted business of 1500 tons was dealt in, and closing sellers' prices were quoted 78s. 1d. cash and 78s. 6½d. one month. On Friday morning again prices continued firm, and a fair volume of business was put through, 3000 tons of Cleveland warrants changing hands at an increase of 3d. to 4d. per ton. Dealings took place at 78s. 3d. per ton cash and 78s. 9d. one month, and at the close sellers' quotations were 78s. 4½d. per ton cash and 78s. 10d. one month. At this, the last session of the year, it was rather remarkable that the prices realised were, besides being the highest of the year, the very highest which have been touched since the period immediately following the Franco-Prussian War, when, at one time in the early seventies of last century, 145s. 7d. per ton was secured for Scotch pig-iron warrants in open market. When the market resumed operations on Tuesday morning, after the New Year holiday, considerable strength was developed in Cleveland warrants, which were bid up to 78s. 10½d. per ton cash, dropping at the close to 78s. 11d., which still marked an increase of 6½d. per ton. For one month's iron, 79s. 6d. was paid, but at the close sellers were quoted down to 79s. 4½d. A turnover of 1500 tons took place. Cash iron advanced to 79s. in the afternoon, one month's warrants rising again to the 79s. 6d. level of the morning, at both figures sellers being over at the close. The business done was again restricted, only 2000 tons being dealt in. This (Wednesday) morning a slightly easier tone prevailed, and cash iron was dealt in down to 78s. 9d. per ton, the closing sellers' price, 78s. 10½d., being 1½d. per ton below yesterday's level, with one month's iron 79s. 4½d. The transactions amounted to 1500 tons. A further decline in cash iron took place in the afternoon, dropping to 78s. 6d., 2000 tons being dealt in at this price. At the close sellers quoted 78s. 7½d. per ton cash, and 79s. 1½d. one month.

Sulphate of Ammonia.—The somewhat sensational advance in the price of sulphate of ammonia, which has been noted within the past two or three months, shows no signs of slacking off, nothing like the present rate having been experienced during the last thirty-three years. Even at the price now ruling there is a constant demand, the British product being increasingly in request. A further advance in price has taken place during the week, and for prompt delivery Glasgow, 17*l.* 15s. to 18*l.* is now quoted and at Leith, 18*l.* 5s.

Scotch Steel Trade.—The year which has just closed has witnessed an extraordinary development in the local steel trade, and a rise in prices which has been nothing short of phenomenal. Even yet, however, no limit of price can be fixed, so long as the cost of raw material continues on the present level, with freight and transport charges so high. During the holiday, which, for obvious reasons, will not be of an extended nature, opportunity is being taken to repair all plant and machinery which has suffered severely from the extraordinary strain of the past few months. The demands of our own and the Allied Governments for all classes of structural steel for war purposes render it an absolute necessity that no time should be lost, and that every machine, every rolling-mill, should be in the best possible condition. Thus only can the necessary output be considered. While efforts are being made to increase the already enormous output, it is doubtful if anything further can be done under existing circumstances. Little else than Government work is now being done, although there are constant inquiries both for home and export. Under existing circumstances it is extremely awkward that everything militates against an increase of export trade, for the necessities of the war demand increased supplies of gold, and if manufacturers cannot undertake the required business a very serious problem will have to be faced sooner or later. Boiler-plates at 13*l.* 10s. and steel plates at 12*l.* 10s. are steady, while angles have eased a trifle since last week, and are now quoted 13*l.* to 13*l.* 10s.—all, of course, less 2½ per cent.

Malleable-Iron Trade.—Little change falls to be recorded in connection with the local malleable-iron trade, the conditions ruling being similar to those of last week. Up to the cessation of activities at the close of the year, the greatest pressure was still evident in all the works. Despite the difficulty of obtaining prompt and adequate supplies of ore, the output is enormous, principally, of course, on Government account, because these demands continue to absorb practically the whole attention of the makers of malleable iron, and ordinary mercantile business is still a feature which may not receive consideration. "Crown" bars for prompt delivery now cost 13*l.* to 13*l.* 10s., less the usual 5 per cent. discount, this price being off and on the same as last week.

Scotch Pig-Iron Trade.—Business in the local pig-iron trade still keeps on a very strong level, with prices on the upward grade; indeed, it is a question as to how much further these will go. Looking back over the year, the chief features of interest have been the falling-off of the export trade, the difficulty of obtaining supplies of ore, and the demand for and the exceptional rise in the price of hematite, which has been consumed in enormous quantities in the local steel works engaged in manufacturing munitions. At the moment the current prices of pig iron are for prompt acceptance only, and it is noticeable that during the past week some of the best brands have put on a matter of about 5s. per ton. Compared with 1913 and 1914, the increase can be described as nothing short of phenomenal. The following statistics relating to the price of makers' (No. 1) iron are worth consideration:—

—	December 31, 1913.	December 31, 1914.	December 31, 1915.
	s. d.	s. d.	s. d.
Clyde	69 0	70 3	98 0
Gartsherrie	69 6	70 3	98 6
Calder	70 0	74 0	97 6
Summerlee	69 6	72 3	97 6
Langloan	70 0	72 0	97 6
Eglinton	64 6	74 6	91 6
Glengarnock ..	74 6	71 6	97 6
Dalmellington ..	65 6	67 6	94 0
Shotts	69 6	71 0	97 6
Carron	71 6	72 6	—

During the past week seventy-one blast-furnaces have been in operation in Scotland—the same number as in the preceding week, and three more than at the corresponding period a year ago. The demand for hematite continues firm, as has now been the case for some time past, while the business prospects of foundry iron have considerably improved.

EXPORTS OF ROLLING-STOCK.—The exports of rolling-stock from the United Kingdom have considerably increased of late years. This is shown by the annexed statement illustrating the value of the shipments during each of the last ten years:—

Year.	Carriages.	Trucks.
1905	502,758	1,504,813
1906	765,351	2,529,031
1907	1,183,858	3,166,369
1908	756,891	2,466,457
1909	363,053	2,013,018
1910	556,053	1,584,294
1911	490,799	1,442,494
1912	831,239	1,829,391
1913	802,483	2,550,807
1914	914,176	3,014,891

The satisfactory growth of the exports is largely explained by the considerable development of railway enterprise in India, Australia, and other parts of our external Empire.

THE TYRANNY OF SPECIFICATIONS.—American machinery-builders, says the *American Machinist*, know more about specifications to-day, particularly foreign ones, than they did a year ago, and it is more than likely that their experience will continue in volume. But it is not at all certain that there has been a complete "meeting of minds" between the offerer and the accepter of all the specifications and contracts for war materials. It is openly stated by persons who should know that many of the contracts for munitions contain a "side-stepping clause." If the material is wanted badly, this innocent-looking detail is overlooked; but should a condition arise where the material was not urgently needed, this harmless-appearing provision might be brought to the surface, insisted upon, and bring about a situation where seller and buyer could not agree. The result might easily be a deal of trouble, if not a virtual or real cancellation of the contract. It is stated that some of these provisions hinge around material, others around limits, and still others around finish. Considering that, according to our American contemporary, *avec le ciel* (in this particular case, foreign buyers of American machinery) *il y a des accommodements*, we fail to see where the "tyranny" of specifications comes in.

LOSS OF WEIGHT OF MUSK.—Fabulous stories have been told about the persistency of the scent of musk and about the extreme dilution of which the vapour is supposed to admit without losing its scent. C. B. Bazzoni (Journal of the Franklin Institute, October, 1915, page 463), of the University of Pennsylvania, exposed 1.32245 mg. of musk, previously dried in an oil-oven at 120 deg. Cent., to a slow current of dry air, and determined the loss of weight daily, or at longer intervals, by means of a "flexure-microbalance," consisting of a quartz fibre rigidly supported in a horizontal position, the pan containing the musk being attached to the free end of the fibre; a sensibility of 0.00007 mg. was thus attained. The small lump of musk lost steadily in weight, the average daily loss decreasing regularly from 0.00318 mg. to 0.00002 mg. in the course of seven months. The loss of weight was not due to loss of moisture. At the end of the seventh month the musk had lost all odour, and remained odourless when freshly moistened, whilst in ordinary cases the odour vanishes when the musk is kept very dry, but reappears on moistening. Thus all the unknown volatile constituents of the musk seemed to have been carried away by the current of dry air in about half a year, whilst it has often been asserted that musk does not lose weight in the course of years. According to Fischer and Penzoldt, one part of musk can be detected in 50 million parts of air.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—The holidays have interfered extensively with the output of house coal. Full work is only now being resumed, after a partial stoppage of nearly ten days, and the reduced output has caused a serious deficit. Merchants state they are helplessly short of supplies. Few collieries have been able even to keep their contracts going, and any free coal on the market is eagerly snapped up at maximum prices. Owners here and there have been endeavouring to obtain another 6d. per ton, but in most cases maximum rates are already in force. Steam coal is in an equally serious position, munition works, railway companies, and factories of all descriptions being caught short of supplies. All are pressing for deliveries. Shippers, too, are short on their contracts, and, with the imperative demand for factory consumption, are likely to experience considerable delay. Nuts and oobbles are equally scarce. Steel coke is firm at from 34s. to 35s., with furnace coke from 24s 6d. to 25s. 6d. Slacks find a very strong demand, but there is practically nothing offered in the open market. The wagon-pooling question is still under consideration by the Board of Trade. Traders are almost unanimously against the scheme, urging that the delay on rail between the collieries and the depôts is the sole cause of the shortage. The latest quotations are as follow:—Best branch handpicked, 20s. 6d. to 21s. 6d.; Barnsley best Silkstone, 18s. to 19s.; Derbyshire best brights, 17s. 6d. to 18s. 6d.; Derbyshire house, 16s. to 17s.; best large nuts, 15s. to 16s.; small nuts, 14s. 3d. to 15s. 3d.; Yorkshire hards, 16s. 6d. to 17s. 6d.; Derbyshire hards, 16s. to 17s.; best slacks, 11s. to 12s.; seconds, 9s. to 10s. 6d.; smalls, 8s. to 9s.

Iron and Steel.—The holidays have been prolonged somewhat beyond anticipation, the overhauling of plant and requisite repairs causing some of the works to remain closed till Tuesday. This, however, has not been the case in munition departments, which have continued, with a brief interval, at full pressure. Notwithstanding the heavy withdrawals of labour owing to enlistment, the output from the works shows an ever-increasing tonnage, drastic reforms in shop management, systematising, and the employment of semi-skilled men and women wherever possible, having had marked effect. There is still, however, room for improvement if sufficient labour were available to secure the continuous working of the rolling-mills, tilts, and hammers, upon which the finished material is dependent. Prices of material of all classes, notwithstanding the effort to fix a maximum, continue on the up grade, and have now reached a figure untouched for nearly fifty years. Quotations at the opening of the year are:—West Coast hematites, 145s.; East Coast hematites, 140s. 6d.; Derbyshire No. 3 foundry, 80s. to 82s.; Derbyshire forge, 79s. to 80s. Bar-iron maintains the recent advance, the basis price of South Yorkshire "Crown" bars being 13*l.* Sheets are quoted at 17*l.* The extraordinary call for high-speed steel continues a feature. Makers can pick and choose their customers and readily dispose of the whole of their output at their own price. A heavy demand exists for all kinds of engineering requirements in the shape of large and small forgings both for shop and marine work. A revival in mercantile shipbuilding is imminent now that certain Government restrictions have been removed, but with the present high price of material only absolutely necessary work will, it is anticipated, be put in hand. There is record activity in the file shops, both on Government and private account. Many of the shops have been largely reorganised and are now worked entirely by female labour.

THE NEW CENTRAL RAILWAY STATION AT LEIPSIC.—In spite of the war the work on the new central railway station at Leipsic—the largest and one of the most imposing in Europe—has been going on, and the work has been finished at or about the stipulated time. Germany has for years expended exceedingly large sums on the building of new railway stations, but the one at Leipsic constitutes a record in this connection. For the use of the Prussian and Saxon lines there are twenty-six passenger lines, along which thirty trains, in or outgoing, can be accommodated. Between these platforms are twenty-seven platforms for mail service and passengers' luggage, connected by a number of tunnels and elevators, &c. A cross-platform affords connection between the central building and the different portions of the railway station. The main structure is 300 m. (985 ft.) long, and covers an area of about 16,000 sq. m. (3.9 acres). It contains two halls, each covering an area of 1700 square metres, in which the Prussian and Saxon departments are installed. From each hall a flight of stairs, 10 m. (33 ft.) broad, leads up to the cross-platform. Between the two halls is a central building, with a passage for the deposit of luggage. The platforms behind the building are covered over to a length of 240 m. (790 ft.), the area being 66,000 sq. m. (16 acres). As an intermediate link between the iron construction of the halls and the central building a monumental arch of ferro-concrete has been erected above the cross-platform. The main station for passenger traffic and the adjoining goods station extend 1½ miles eastwards, 1.4 miles northwards, and 1 mile westwards. The rail system has an aggregate length of 93 miles. The time-table for normal peace traffic provides 500 trains in the day to be worked within the new station. The aggregate cost of the new Leipsic railway station amounts to 135,000,000 marks (6,750,000*l.*), of which 53,000,000 marks have been debited to Prussia, 60,000,000 marks to Saxony, 5,000,000 marks to the Imperial German postal service, and 17,000,000 marks to the city of Leipsic.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Home and Continental consumers of pig-iron are pressing for deliveries against contracts. In some cases such deliveries are considerably in arrear, owing to scarcity of labour, shortage of trucks, and difficulty experienced in arranging suitable tonnage. Values of Cleveland pig have this week once more advanced to higher rates than have been paid for many years past. With the exception of business in No. 3, at 80s. in 1900, more has been paid than since 1874. In 1873 the highest on record was realised, viz., 120s. No. 3 has this week changed hands at 79s. 6d., but the position has eased a little, and the ruling quality is now obtainable at 79s.; whilst No. 1 is in the neigbourhood of 82s. 6d.; No. 4 foundry, 78s. 6d.; No. 4 forge, 78s.; and mottled and white iron each 77s. 6d.—all for early delivery.

Stocks of Cleveland Pig-Iron.—What quantities of Cleveland pig are lying at makers' yards are not ascertainable, but they are stated to be by no means large. At the end of December there were in the public warrant stores 113,046 tons, all of which is No. 3 quality. During the last month of the year 13,785 tons were taken from the stores, and there are now warrants in circulation for 100,300 tons.

Hematite Iron.—There is no East Coast hematite pig-iron purchasable for supply before the second quarter of the year. Continued very good inquiries are reported both from home consumers and from customers abroad, our Allies in particular showing desire to place further orders. Despite suggestions that the maximum should be less, buyers are not only ready, but rather keen, to arrange contracts at 130s. for Nos. 1, 2, and 3, delivered April next and onward. That is regarded as the general market quotation, though some sellers are inclined to name up to 135s.

Foreign Ore.—There is little or nothing new to report concerning foreign ore. Consumers report very ample supplies coming to hand, and for the time being are not anxious to place orders. So far the efforts to base quotations on a maximum of 34s. ex-ship Tees for Rubio of 50 per cent. quality has not been successful, the basis now being 38s. Freights Bilbao-Middlesbrough remain firm at 21s. 6d. Imports of foreign ore to the Tees to date, this month, amount to 30,983 tons.

Coke.—Sellers of coke are in a strong position, but buyers, in view of fixed maximum prices being considerably below what sales have recently been made at, are holding off as much as possible. Large quantities, however, are still needed for customers, both at home and abroad. Durham beehive blast-furnace coke, of good medium quality, is quoted in the neighbourhood of 33s., delivered at Teeside works. Foundry coke for shipment is quoted at 36s. to 37s. 6d. f.o.b.

Manufactured Iron and Steel.—Manufacturers of finished iron and steel continue fully employed on Government work, and are still being pressed for deliveries. The congestion is such, in fact, that there is very little opening for private trading, and any small parcels that become available for ordinary commercial disposal are quickly taken up at considerably above scheduled rates. Prices all round are firm. The following are among the principal market quotations:—Common iron bars, 13*l.*; best bars, 13*l.* 7s. 6d.; double best bars, 13*l.* 15s.; treble best bars, 14*l.* 2s. 6d.; iron ship-plates, 11*l.*; iron ship-angles, 13*l.*; iron ship-rivets, 15*l.*; steel sheets (singles), 13*l.* 10s. to 14*l.*; steel sheets (doubles), 13*l.* 15s. to 14*l.* 5s.; steel ship-plates, 11*l.*; steel ship-angles, 10*l.* 15s.; steel boiler-plates, 13*l.*; steel strip, 13*l.*; steel hoops, 13*l.* 5s.; steel joists, 11*l.*; heavy sections of steel rails, 11*l.* to 11*l.* 10s.; and steel railway sleepers, 12*l.* to 12*l.* 10s.—all less 2½ per cent. discount, except rails and sleepers, which are net at works.

Tees Iron and Steel Shipments.—Shipments of iron and steel from the port of Middlesbrough during the last month of 1915 were on a very satisfactory scale. Those of pig-iron totalled 56,716 tons, as compared with 48,036 tons for the previous month and 21,450 tons for December a year ago. Of the pig despatched last month, 54,871 tons went abroad and 1845 tons coastwise, the largest importers being France, 27,501 tons; Italy, 10,144 tons; Sweden, 4020 tons; America, 3248 tons; Japan, 3096 tons; Norway, 2965 tons; and Denmark, 2920 tons. Of the 5077 tons of manufactured iron shipped last month, 2616 tons went to foreign countries and 2461 tons to coastwise customers, India, with an import of 2371 tons, being by far the largest customer. Loadings of steel in the last month of the year reached 25,094 tons, 23,877 tons going abroad and 1217 tons coastwise. France was the largest receiver of steel, taking 12,214 tons, India being second with 3534 tons, and Japan third with 3194 tons.

Middlesbrough Shipbrokers' Association.—The recently-formed Middlesbrough Shipbrokers' Association promises to prove useful and beneficial. Composed, as it is, of gentlemen with a wealth of information which can be used to advantage by the public authorities that have control of the waterways of the iron district, the formation of the association has met with general approval. With the Government making important and stringent demands upon the shipbroker in respect of imports and exports, many arrangements may be made through the association with greater facility than by individual effort. Mr. John W. Brown, of the well-known firm of Messrs Hanson, Brown and Co., is the courteous and able honorary secretary.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The past week has been rather of a holiday character, and in many cases inquiries have been held over. Colliery-owners, whose stocks are not excessive, are still anticipating pressure, and quotations have been well maintained for all classes of large and superior smalls. The best Admiralty large steam coal has been, to some extent, nominal; secondary qualities have made 25s. to 25s. 6d.; best bunker smalls, 14s. to 15s.; and cargo smalls, 6s. to 9s. per ton. The best household coal has brought 23s. to 24s.; good households have realised 21s. to 22s.; No. 2 Rhondda large has made 20s. to 21s., and No. 2 smalls have been quoted at 11s. to 11s. 6d. per ton. The latest quotation for patent fuel has been 24s. to 25s. per ton. Special foundry coke has made 42s. to 45s.; good foundry coke, 38s. to 42s.; and furnace coke, 32s. to 35s. per ton. As regards iron ore, Rubio has realised 35s. to 37s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Western Trade Matters.—The Welsh tin-plate works will be controlled, to a considerable extent, by the Government this year. The intention is to control the trade as a whole; the business of the various works will be interfered with as little as possible, but under the new system the Government will be in a position to take and deal with the output as it thinks fit. The output of the majority of the works is being taken now by the Government and its Allies.—Mr. W. T. L. Linton, who has recently arrived in this country from the Welsh Colony of Hugheskoffka, in Southern Russia, has been appointed by the British Serbian Engineering Company, Limited, to represent the company at Petrograd and Moscow. Mr. Linton is a son of Mr. T. E. C. Linton, of Cardiff. —The steamer Edo, purchased by the Branksome Chine Steamship Company, Limited, is to be re-named the Branksome Chine; she was built in 1906, and the sum paid for her last year was 35,000*l.*—The death is announced, in his eighty-seventh year, of Mr. Alderman Moses, of Newport. In early life Mr. Moses was agent at Newport for Messrs. Harford Brothers, who were the predecessors of the Ebbw Vale Steel, Iron, and Coal Company, Limited; subsequently he went into business on his own account as a merchant and ship-broker.—The managers of the W. and C. T. Jones Steamship Company, Limited, recommend an interim dividend for the past half-year at the rate of 20 per cent. per annum.—The Tatem Steam Navigation Company, Limited, has paid an interim dividend of 10 per cent.—The shipments of coal from the seven principal Welsh coal ports last year were sharply reduced by the war. They amounted for the twelve months to 25,523,736 tons, as compared with 34,009,476 tons in 1914, 41,413,243 tons in 1913, and 36,238,494 tons in 1912. The Cardiff shipments for the four years were:—1915, 13,909,593 tons; 1914, 21,350,283 tons; 1913, 26,588,184 tons; and 1912, 23,486,481 tons.—During the past year new offices for the British Mannesmann Tube Company were continued to the point of completion, but the construction of new works which had been proposed has been suspended. There has recently been an improved outlook, a new company having appeared upon the scene under the style and title of the United Tube Corporation, Limited, with the view apparently of taking up some of the extensions contemplated by the Mannesmann interest. —Within easy reach of Port Talbot is a great section of the South Wales coal-field which has been scarcely touched at present. This is likely to be developed, as firms having the command of considerable capital are now only awaiting the termination of the war before proceeding energetically with pits already started and commencing new sinkings in areas thus far untouched.—In spite of the war, foreign shipments of coal from Port Talbot amounted last year to 1,447,531 tons, as compared with 1,423,468 tons in 1914; in 1913, however, they amounted to 1,880,090 tons, and in 1912 to 1,621,385 tons. —The imports of iron ore into South Wales last year were estimated at 1,560,000 tons, as compared with 1,315,321 tons in 1914 and 1,578,179 tons in 1913; the greatest progress shown in last year's imports occurred at Newport, which imported 380,000 tons.—The directors of the Aberthew and Bristol Channel Portland Cement Company, Limited, report a profit of 10,993*l.* for 1914-15; no dividend is recommended, but a loss of 1899*l.* sustained in 1914 has been made good; and after payment of interest on debentures and writing off preliminary expenses, 1061*l.* is carried forward. To meet an anticipated demand for cement at the termination of the war, the directors have decided to erect a third kiln.

THE SUEZ CANAL.—The number of vessels which passed through the Suez Canal in 1914 was 4802, representing a net tonnage of 19,409,493 tons, and a revenue of 4,867,200*l.* In 1913 the number of vessels using the canal was 5085, having an aggregate net tonnage of 20,033,884 tons, and yielding a revenue of 5,036,400*l.* In 1912 the number of vessels was 5373, their net tonnage was 20,275,120 tons, and they produced a revenue of 5,428,800*l.* The war has slightly reduced the business of the canal. Of the vessels which passed through the canal last year 3078 were British, as compared with 2951 in 1913; 481 German, as compared with 778; 347 Dutch, as compared with 342; 228 French, as compared with 256; 176 Austro-Hungarian, as compared with 246; and 131 Italian, as compared with 110. The number of military passengers who passed through the canal in 1914 was 228,720, as compared with 88,748 in 1913. The movement of civilians declined in 1914 to 155,183, as compared with 169,641; the number of pilgrims and emigrants was 7869, as compared with 23,846.

SELF-ACTING BORING-MACHINE FOR PROJECTILES.

CONSTRUCTED BY MESSRS. SWINNEY BROTHERS, LIMITED, ENGINEERS, MORPETH, NORTHUMBERLAND.

Fig. 1.

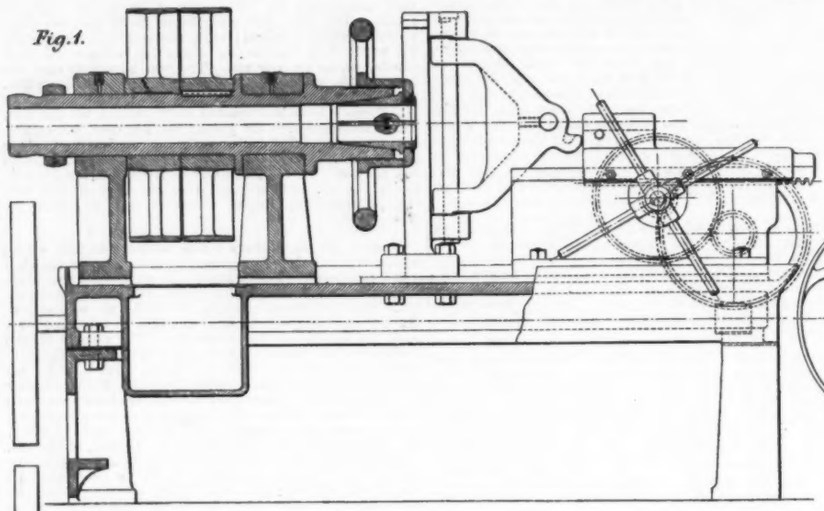


Fig. 3.

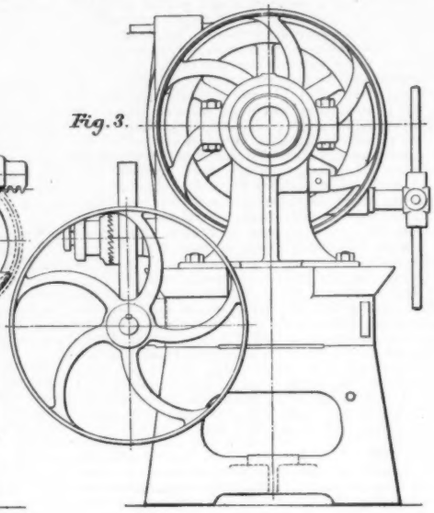


Fig. 2.

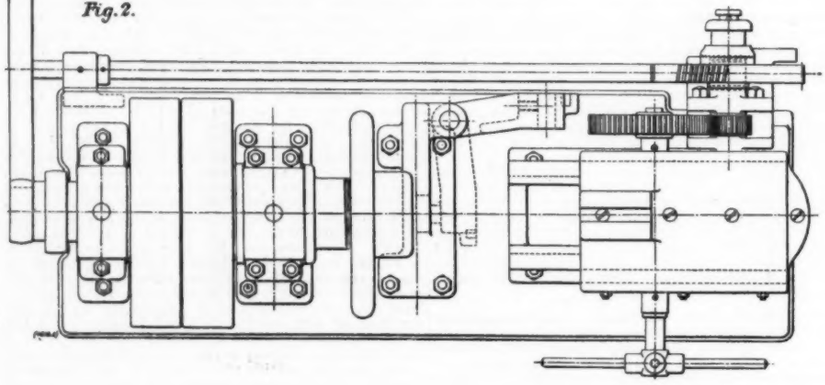
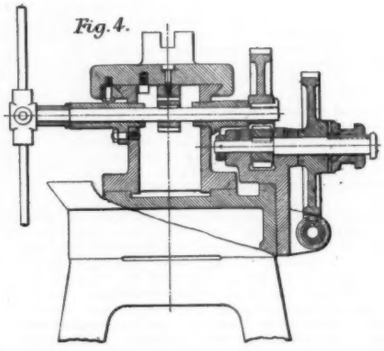


Fig. 4.



We illustrate on the present page a self-acting boring-machine for shells, constructed by Messrs. Swinney Brothers, Limited, of the Wansbech Iron Works, Morpeth, Northumberland, this machine being intended to deal with 13-pounder, 15-pounder, 18-pounder, and 75-mm. shells. The design of the machine is very simple. The heavy hollow spindle is driven by belt direct, and carries at its front end a chuck for holding the shells, while at the rear end the exterior is turned to form a small pulley, from which a belt extends to a larger pulley on the shaft at the back of the machine, by which the feed motion is given to the boring-tool.

The machine is geared to drill a hole 1¾ in. in diameter at the rate of 1 in. deep per minute, and at this speed, the makers inform us, nine 18-pounder shells can be centred and drilled per hour. The rapid centring of the shells is facilitated by the use of the substantial swinging radial arm, which forms a special feature of the machine. The arrangement is clearly shown by the engravings, Figs. 1 to 4.

As shown by the photograph reproduced in Fig. 5, the machine is fitted with a foot-brake for stopping it promptly when a shell is finished; but since this photograph was taken the makers have added a second foot-brake, which acts on the hand-wheel by which the clutch is closed. By a momentary pressure on the pedal of this brake when the machine is started the clutch is closed and the shell fixed. This renders the operation of the machine easy work, even for female labour.

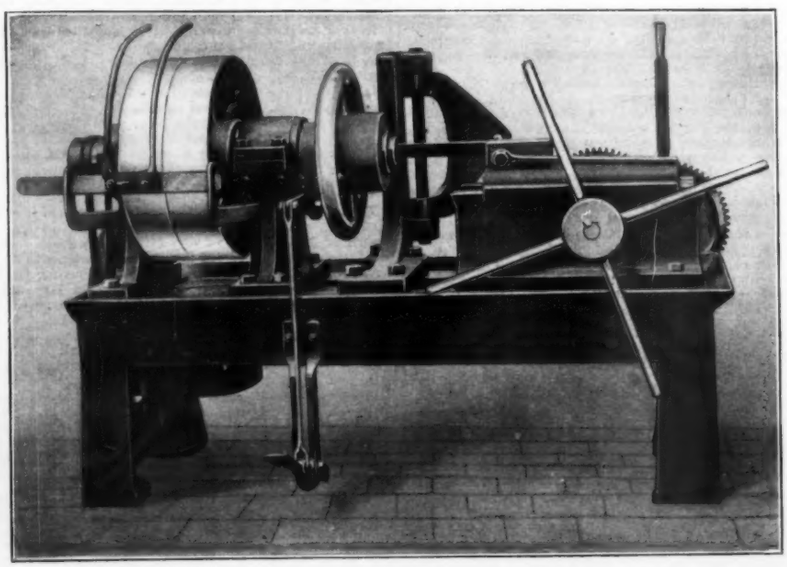


FIG. 5.

SOUTH INDIAN RAILWAY.—The Indo-Ceylon connection of the South Indian Railway is being worked at a considerable loss, and proposals have been submitted to the Ceylon Government that the company should either discontinue the working or reduce the working to an occasional passenger train. It appears from inquiries made at Colombo that negotiations for future management are proceeding with the administration of the Ceylon Government Railway; but in any case it is now assured that the present service will not be discontinued, although it may be attended with occasional difficulties.

THE INSTITUTE OF MARINE ENGINEERS.—The annual meeting of members will be held in the new premises of the Institute, Minories, Tower Hill, on March 31, at 7 p.m., when it is hoped there will be a full attendance to receive the annual reports and transact the business in connection therewith.

A GREAT CANADIAN TUNNEL.—The great Rogers Pass Tunnel on the main line of the Canadian Pacific Railway has just been carried through from end to end, although it is not yet finally completed. The tunnel is 5 miles long, and it will have lengthy approaches; at some points it is 6000 ft. below the surface.

THE HYDRO-ELECTRIC POWER WORKS AT LAKE MARGARET, TASMANIA.

(*For Description, see Page* 3.)

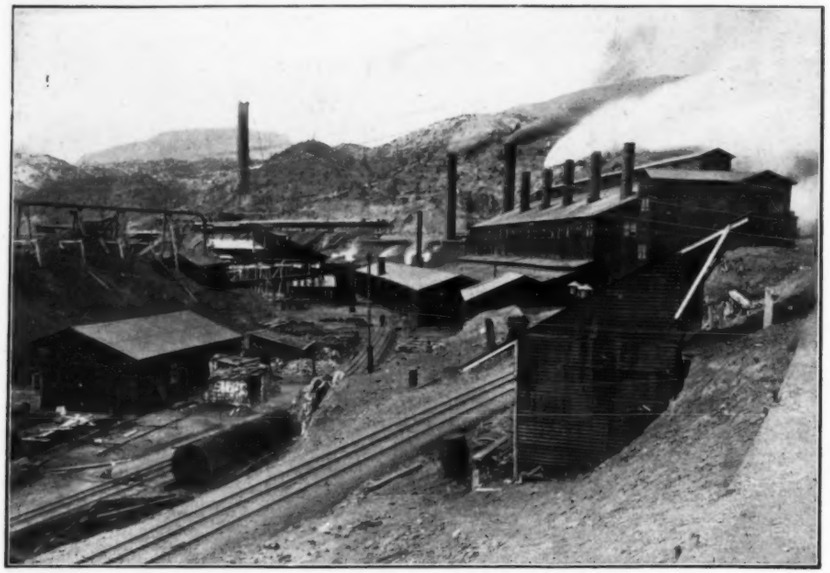
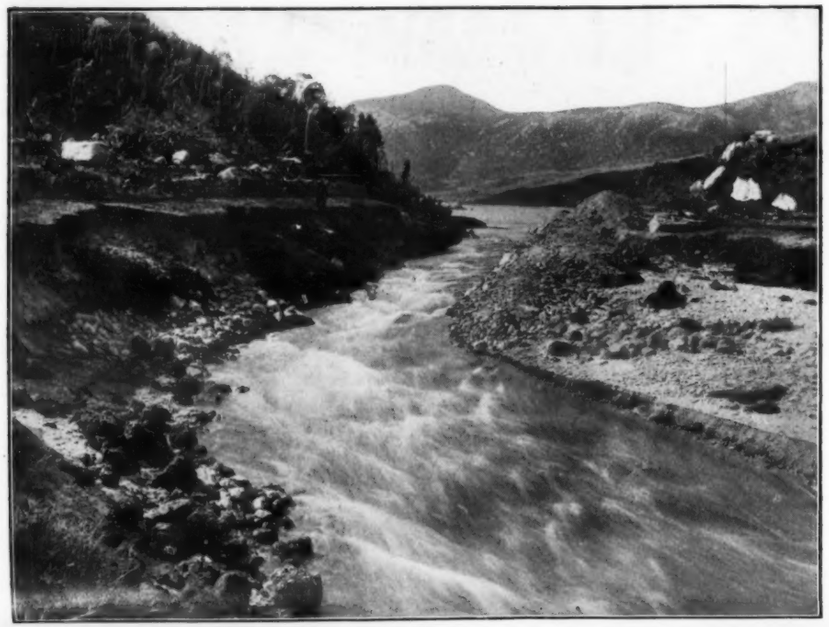


FIG. 1. VIEW OF SMELTING WORKS.

FIG. 2. GENERAL VIEW OF LAKE MARGARET.



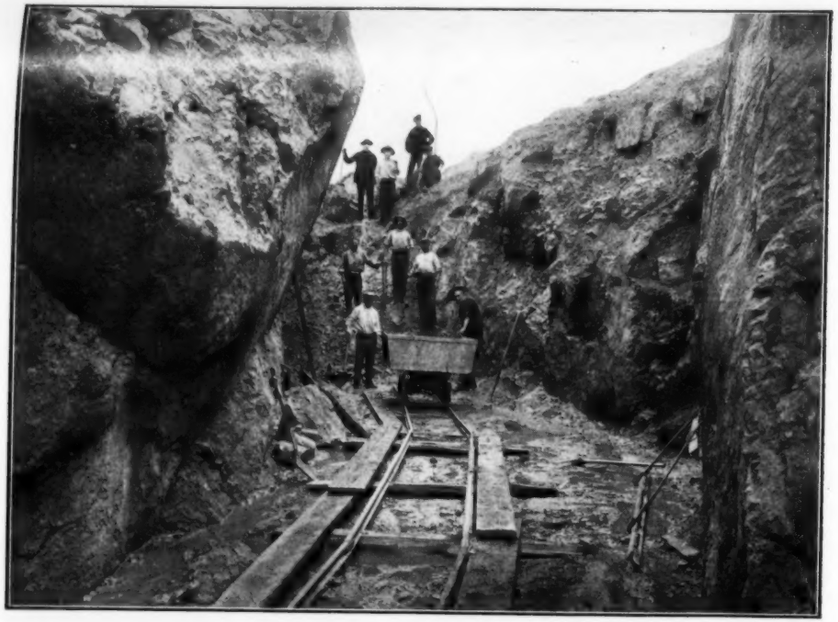


FIG. 5. DISCHARGE CHANNEL DURING EXCAVATION.

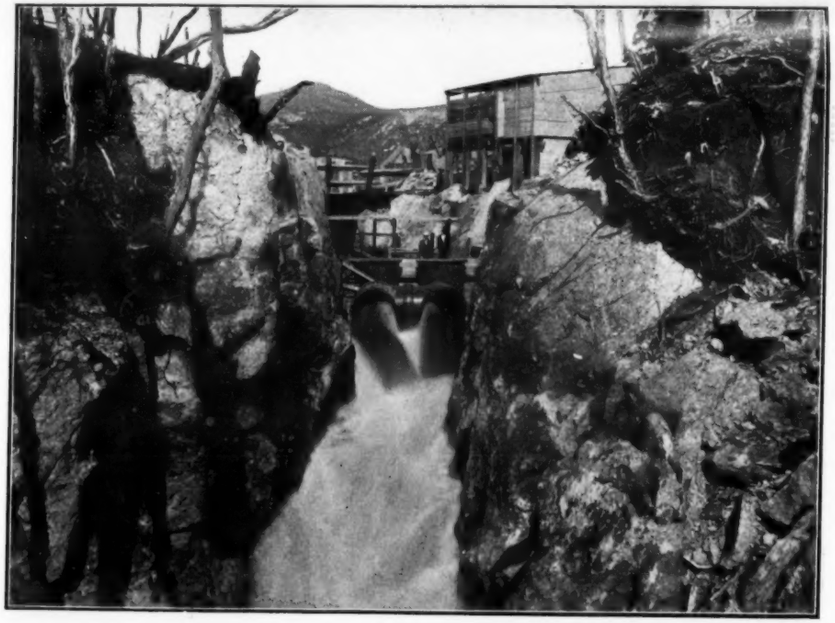


FIG. 6. DAM DURING ERECTION, SHOWING DISCHARGE-PIPES.

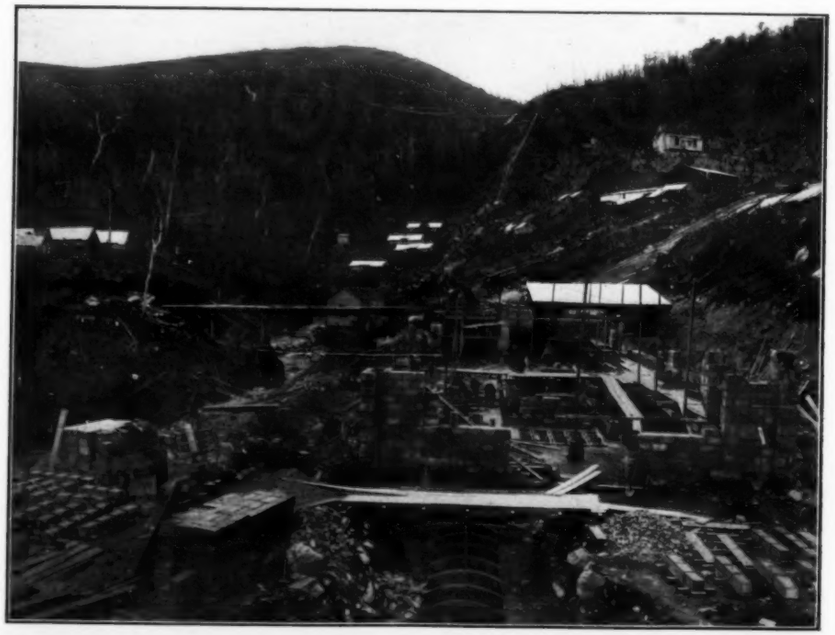


FIG. 7. VIEW OF STEEL PIPE LINE DURING CONSTRUCTION.

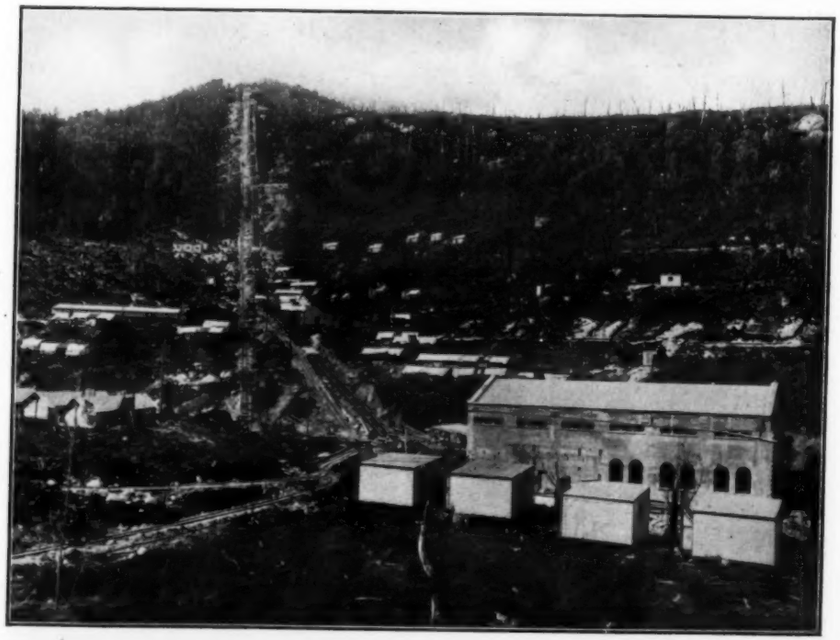


FIG. 8. VIEW OF STEEL PIPE LINE DURING CONSTRUCTION.

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmott and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Manning Chambers. Montreal: Sells, Limited, 302 Shaughnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Subscriptions and Advertisements, Librairie E. Tignol, 53bis, Quai des Grands-Augustins, Paris. Also for Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Ltd.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland, and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Long-street.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
UNITED STATES. For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue. Chicago: H. V. Holmes, 927-933, Monadnock Block. For Advertisements, J. S. Allan, 508, Stratford Avenue, Bridgeport, Conn., U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

"ENGINEERING" may be ordered from any Newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom..... £1 15 6

The increase in the annual subscription is entirely due to the new postage rates on newspapers.

For Canada—

Thin paper copies £1 11 6 ($7.65)
Thick „ £1 16 0 ($8.75)

For all other places abroad—

Thin paper copies £1 16 0
Thick „ £2 0 6

When foreign subscriptions are sent by Post-Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3063 and 8598 GERRARD.

"ENGINEERING" CLASSIFIED DIRECTORY OF CURRENT ADVERTISEMENTS.

The OCTOBER EDITION in compact book form is now ready and may be obtained gratis from the Publisher. It also contains the Telegraphic Addresses, Codes, and Telephone Numbers of our Advertisers, and Glossaries for the use of Foreign Buyers in Russian, French, Italian, and Spanish.

CONTENTS.

	PAGE		PAGE
Stable Biplane Arrangements (*Illustrated*)	1	Secondary Stresses	13
The Lake Margaret Hydro-Electric Power Works (*Illustrated*)	3	Gases in Coal-Mines	14
Industrial Notes	7	The Life of Concrete Structures	15
Year-Books and Annuals ..	8	The German Electrical Industry.....	16
Diagrams of Three Months' Fluctuations in the Prices of Metals.....	9	Notes	16
Notes from the United States	10	Literature: The Rare-Earth Industry.....	17
Notes from the North	10	Books Received	18
Notes from South Yorkshire	11	Honours for Engineers	18
Notes from Cleveland and the Northern Counties ..	11	Shells; More Shells.....	18
Notes from the South-West	11	Phosphorus in Iron and Steel (*Illustrated*)	19
Boring-Machine for Projectiles (*Illustrated*)	12	Electrical Railways (*Illustrated*).....	22
		Colonial and Foreign Engineering Projects	24

With a Two-Page Plate of the HYDRO-ELECTRIC POWER WORKS AT LAKE MARGARET, TASMANIA.

NOTICES OF MEETINGS.

THE SURVEYORS' INSTITUTION.—Monday, January 10, 1916, when a paper entitled "Some Notes on Reinforced Concrete" will be read by Mr. R. M. Kearns (Fellow). The chair will be taken at 5 o'clock instead of 8 o'clock.

THE INSTITUTE OF MARINE ENGINEERS, INCORPORATED.—Tuesday, January 11, at 7 p.m. Paper entitled "Power-Driven Tools on Board Ship," by Mr. J. Hamilton Thomson.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 11, at 5.30 p.m. Paper to be submitted for discussion:—"The Electric Locomotive," by Mr. Frederick William Carter, M.A., Assoc. M. Inst. C.E. And ballot for new members.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, January 11, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. A discussion on "Some Principles in Industrial Lighting (with Special Reference to the First Report of the Departmental (Home Office) Committee on Lighting in Factories and Workshops)," will be opened by Mr. J. S. Dow.

THE INSTITUTION OF ELECTRICAL ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, January 12, at 7 p.m., at the University, Edmund-street, when Professor Miles Walker, M.I.E.E., will read his paper entitled "The Predetermination of the Performance of Dynamo-Electric Machinery."

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, January 12, at 8 p.m., at St. Bride's Institute, Bride-lane, Fleet-street, E.C. A paper will be read by Mr. W. H. Booth, F.G.S., M. Am. Soc. C.E., on "Limit-Gauges and their Application."

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Wednesday, January 12, in the Hall of the Royal Society of Arts, John-street, Adelphi, W.C., at 8 p.m., when Mr. Geo. W. Watson will read a paper entitled "Back Axles."

THE LIVERPOOL ENGINEERING SOCIETY.—Wednesday, January 12, at 8 p.m., at the Royal Institution, Colquitt-street, when a paper will be read by Mr. J. Wemyss Anderson, M.Eng. (Liverpool), M. Inst. C.E., M.I. Mech. E., entitled "Marine Refrigeration."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, January 13, at 8 p.m. "The Predetermination of the Performance of Dynamo-Electric Machinery," by Professor Miles Walker, Member.

ENGINEERING.

FRIDAY, JANUARY 7, 1916.

SECONDARY STRESSES.

VERY little of the structural steel work erected is really statically determinate, but it is comparatively seldom that this fact is explicitly recognised by those responsible for its design. In practice it is usual to class as indeterminate only such structures as rigid arches, stiffened suspension bridges, and the like, and it has long been recognised that the adoption of such types in suitable conditions effects a considerable economy in material. In other cases the stresses arising from the real rigidity of ordinary bridge and roof trusses are classed as secondary stresses, and some engineers appear to be of opinion that such secondary stresses may seriously compromise the safety of structures which, apart from this, would be thoroughly trustworthy. For instance, one of the explanations originally advanced for the collapse of the Quebec Bridge was the existence of certain secondary stresses at the base of the main towers. The report of the Royal Commission effectually silenced fancy hypotheses of this character, although opinions as to the practical significance of secondary stresses still vary widely. Most of the plates and shapes turned out by American mills are used for structural steel work, whilst in this country the major portion of our output is built into the hulls and superstructures of ships. It is easy in the case of bridges and roofs to reduce indeterminateness of stress to a minimum, whilst in ship work an attempt to do this would be disastrous. Further, the loads to be carried by bridges and roofs can be estimated with some approach to accuracy, but knowledge as to straining actions to which ships are subject is necessarily somewhat vague and indefinite. It is perhaps in part due to this difference in the disposal of the make of steel in the two countries that English engineers have alway been inclined to attach less importance to calculated stresses as the sole criterion of safety than would appear to be the case on the other side of the Atlantic.

Many American engineers still appear to be perturbed by calculations showing the existence of large secondary stresses in bridge work of a type which experience has proved to be thoroughly satisfactory in practice. Thus in a recent issue of the *Engineering News*, Mr. R. L. Manville, Engineer of Structures, New York Central Railway, discusses the secondary stresses which arise in the bent of an overhead railway when the two supporting columns are firmly bracketed to the girder connecting them. In such a case, a considerable bending moment is, of course, developed at the junctions between column and girder, which can be readily calculated on certain reasonably correct assumptions. We shall not reproduce here the formulæ at which Mr. Manville arrives, since the methods of determining such stresses are now well known to most engineers interested in structural work; but in discussing his results Mr. Manville makes certain recommendations, and attaches an importance to secondary stresses which appears to us to be at least open to argument. For example, he observes that columns supporting such a bent should be slender in the plane of bending, so as to reduce the secondary stresses to a minimum. This policy seems highly debateable, and we are strongly of opinion that actual test would prove that with the same total weight of metal, the factor of safety of the structure would be considerably greater if an opposite policy were followed and the columns made very stiff in the plane of the secondary bending moments.

The point ultimately at issue is really how far can a calculated stress be taken to be a measure of the factor of safety of a structure. There is, of course, a school of engineers anxious to banish into limbo such a term as the "factor of safety," which has frequently, but inadequately, been defined as a "factor of ignorance." In very many cases, at any rate, it is really "a factor of knowledge." The engineer, in short, knows more than his formulæ, and if these give results at variance with his experience, it is the latter on which the competent engineer will rely.

A structure may, in fact, have moderate working stresses and yet the factor of safety may be dangerously low. Such a condition is well exampled by the German cranes constructed for Panama by the Deutsche Maschinen-Fabrik, Duisberg. It may be noted that a crane built by the same makers had collapsed a few years previously in this country, so that the builders have evidently learnt little by experience. This is commonly the case when design is entrusted to computers in place of to experienced engineers. Conversely, it is quite possible to have apparently excessive working stresses in conjunction with a large factor of safety. Conceive, for example, a girder resting on two abutments and carrying a dead load producing a fibre stress of, say, 16 tons per sq. in. At mid span let a pier or column be set up, clearing the girder above by, say, $\frac{1}{100}$ in. In such a combination the working stress is very high, but the factor of safety is also high, since the moment the girder began to fail it would come into contact with the central pier. Another example illustrating how loose the connection between a working stress and a factor of safety may be is afforded by chains, the proof stress on which, as determined on the usual assumptions, is of the order of 30 tons per sq. in. Nevertheless, chains carry their designed loads satisfactorily. It will be noted that they are never called upon to stand reversals of stress.

If we define a secondary stress as one which will automatically be reduced by an incipient failure of the part stressed, a definition which is, we believe, a fair one, it stands to reason that even large secondary stresses may be of relatively little importance, and, in fact, we have never heard or known of a case in which the failure of a roof or bridge member not subject to alternating forces has been traced to the existence of secondary stresses as thus defined. It is just possible, however, that failure might occur even in the absence of actual alternation of the stress, if this stress, although not changing sign, ranged, nevertheless, between very wide limits.

Of course, the failure of a column by crippling arises from secondary stresses of a kind, but the type here involved are not in any way analogous to the secondary stresses developed when a girder is rigidly secured to a supporting column. The web stresses in the case of a column, in short, increase as failure by crippling proceeds, and thus do not conform to the definition above given.

Mr. Manville insists on the importance of calculating the value of secondary stresses. With what object can such a calculation be made? It may be made, in the first place, with the object of redesigning the structure so as to eliminate secondary stresses entirely, although experience with the resultant loosely-connected edifices has been far from satisfactory. If, on the other hand, the secondary stresses are determined with the object of allowing for them, on what basis is this allowance to be made? No legitimate method of fixing working stresses *à priori* exists. The true test as to whether a stress is or is not safe is whether or no failure arises from it in practice, and in the case of secondary stresses experience points wholly in the direction of their practical insignificance. Of

course, the very existence of a secondary stress implies the relief elsewhere of stresses calculated on the usual hypotheses, and it would be quite a legitimate objective to determine the secondary stresses with a view to economising material, but in most cases the saving would be insufficient to offset the labour involved, and it may safely be asserted that this is never the objective of the engineer who is perturbed by the rigidity of the joints of his trusses.

The nearest approach to a failure of a structure due to secondary stresses with which we are acquainted was that of an old arched bridge in Wales, on which the late Sir Benjamin Baker once reported. The bridge consisted of a pair of arched members, each of which was compounded of two arched ribs of very different ratios of rise to span, firmly joined together at their mutual intersections. The joints between the two components at these intersections were constantly failing and having to be renewed, but the safety of the structure as a whole was, in Sir Benjamin Baker's opinion, not compromised, and he advised the adoption of a sliding connection between the components in place of a rigid one. He held that, though this ancient design was not one to be repeated, yet the second rib did serve somewhat to stiffen the structure. In this case it should be noted that the principal stresses on the joint arose from changes of temperature, and were thus alternating in character, and it is undoubtedly of prime importance to calculate, and allow for, secondary stresses if they be of this type. In fact, under alternating stresses the natural elastic limits of a material have probably a somewhat close connection with its working strength; but no such relationship can, in general, be traced when the load is steady, and the most scientific method of proportioning parts in such cases consists in the use of factors of safety based on experience with the material under similar conditions of stress.

It has been shown mathematically by Dr. K. Suyehiro that if a small hole be drilled in a tension member, the maximum stress at the edge of the hole is three times the mean stress on the bar. This result has been confirmed and extended by Mr. C. E. Inglis in a remarkable paper read before the Institution of Naval Architects in 1913. At the same meeting at which the paper by Mr. Inglis was read, Mr. (now Sir) Archibald Denny incidentally recounted experiences showing the danger of these secondary stresses when alternating. He observed that window-openings in the deck-houses of Atlantic liners were very liable to crack at the corners. Such deck-houses are subjected, it appears, to very heavy alternating stresses, and it is, in fact, found desirable to interrupt their continuity by means of sliding joints.

On the other hand, openings in structures not subject to alternating stresses have proved much less dangerous than would be anticipated were the elastic limit of the material a measure of its safety. The high stresses found at the edges of a hole are strictly of a secondary character, as defined above. A very small plastic yielding accordingly suffices to transfer the overload on to the less heavily strained portions of the metal, and this transfer is apparently satisfactorily effected even with brittle materials like cast iron. Were this otherwise, it would be necessary to make the metal in the neighbourhood of the indicator-cocks of a steam-engine cylinder three times as thick as the body of the latter, and it would be dangerous to drill the usual touch-hole in the barrel of one of the old muzzle-loading guns.

In a great many cases engineers have to proportion parts with but the very vaguest idea as to the actual stresses to be provided for. No one, for example, knows what is the maximum safe working stress on an automobile axle. All that can be done is to assume that if a certain size is found safe in practice under a "dead" axle load of, say, ½ ton, that an axle of double the strength under static load will be safe when the dead load to be carried is 1 ton. This, in fact, amounts to the assumption that the true maximum stress on the axle in service will be proportional to the dead load. This maximum stress will, however, obviously be much higher than the dead-load stress, since every time the wheel drops into a rut in the road the dead-load stress will be increased to an unknown, but certainly very serious, degree. Even if steps were taken to obtain a record of these inertia stresses, it is doubtful whether any marked improvement could be effected in the actual proportions and designs which have been arrived at as the result of experience on a large scale. It is even more doubtful whether an exact analysis of secondary stresses in ordinary bridge structures will lead to any marked improvements in design. In fact, there is not a little reason for fearing that the effects of such a calculation would be reactionary, since it requires a certain strength of mind for an engineer to oppose his experience, that a certain structure is safe, against a calculation which shows that the stress in certain parts exceeds 10 or 11 tons per square inch. He is very much inclined to modify his designs for the worse by eliminating the secondary stresses as far as possible, a procedure that in most cases results in a much less satisfactory, because less rigid, structure.

In this connection it is interesting to recall Mr. Foster King's observation at the Institution of Naval Architects in 1913, that small changes in conditions of operation or the like lead every now and then to sporadic outbreaks of minor failures in ship structures, a phenomenon which he attributes to the closeness with which practice follows the dividing line between success and failure. Experience, it would seem, has led to just the proportions necessary under normal conditions, and if these are varied in any way, partial failures of some sort or other are liable to occur. These are eliminated by suitable modifications in design or scantlings, and no further trouble is then experienced until still another departure is made from the normal.

As a matter of fact, it is certain that local stresses in riveted structures commonly exceed 13 to 14 tons per square inch, and it is impossible to avoid such stresses. Pin connections may possibly be worse still, since Dr. Suyehiro has shown that whilst in the case of an open hole the stress is locally three times the mean, in a properly filled rivet-hole it is only twice the mean. Since secondary stresses of this character give rise to no trouble in practice, it seems unreasonable to attach great importance to the secondary stresses at the rigid connections between columns and girders, or in the neighbourhood of the joints of riveted structures. Of course, in the foregoing the secondary stresses in view must satisfy the definition above set forth. It cannot be denied that the bracing of latticed struts is often most inadequate, and observations and calculations on the stresses in such parts are of the highest importance. The stresses here in question do not, however, satisfy the condition that an incipient yield of the part affected tends to relieve the stress, and it is illogical to group together stresses of this kind with those in which the contrary is the case.

Mr. Manville, it is true, observes that the satisfactory record of structures subject to large secondary stresses does not warrant a total disregard of such stresses. Surely, however, the true test of a satisfactory structure is the manner in which it carries its load, and not the accuracy of the engineer's knowledge as to the actual value attained by the working stresses. Much, however, depends on the importance to be attached to the qualifying adjective "total." In certain cases, as we have pointed out above, secondary stresses may be of very serious importance; but in other cases, and particularly in bridge work, there is no evidence that secondary stresses of the character here discussed have ever been a source of danger, and, in general, the rigidity resulting from their presence is an actual advantage.

A rule which has the sanction of much experience is that a statically indeterminate structure subject to a non-alternating stress is safe if it appears safe under any assumed distribution of the stresses satisfying the conditions of internal and external equilibrium. If the stresses thus calculated be moderate, the safety of the structure may generally be taken as assured. Hence it is legitimate to treat a riveted truss, which is, of course, really a statically indeterminate structure, as if it were hinged at every joint, and the resultant structure is safer than if the secondary stresses were suppressed by actually adopting hinged joints. In other words, for the same real factor of safety a riveted truss may be lighter than a pin-connected one.

Calculated on this principle, the famous Bear Valley Dam appeared to be perfectly safe, whilst when the stresses were computed by the mathematical theory of elasticity, the values found, in certain regions, were enormously greater than are considered admissible on masonry. A number of curved dams have since been built in Australia, and have proved satisfactory. The stresses in them have been computed in accordance with the rule above given, and it is certain that the secondary stresses attain values far in excess of those thus found.

No doubt there are limits to the applicability of this simple rule; but that it is more trustworthy, even in extreme cases, than rules based upon the mathematical theory of elasticity is demonstrated very remarkably by Professor Bridgman's experiments on the bursting strength of thick cylinders. These cylinders invariably commenced to fail at the external, in place of at the internal, surface; though, according to the usual theory, the stress is a maximum at the inner radius. What actually happened was that the inner surface stretched enormously, thus equalising the stress over the wall section. Even in the case of tool-steel a stretch of 120 per cent. was recorded without rupture of the metal, whilst with copper a stretch of 300 per cent. was attained. Mr. Gerald Stoney, again, has recorded the case of a turbine-wheel which, through inadvertence, was run up to a speed of 8000 revolutions per minute, instead of the intended 5000 revolutions per minute. The hole in the disc took a permanent increase of ¼ in. in its diameter, but no failure occurred. Naturally, in very many cases large distortions are inadmissible for practical reasons, and the stresses must accordingly be calculated by the theory of elasticity, even although the load to be taken is perfectly steady in character.

GASES IN COAL-MINES.

THE origin and liberation of gases, commonly occurring in coal-mines, is not less obscure than the whole coal-constitution problem, though it might be thought that this particular problem would admit of relatively easy investigation. It cannot be said that the study of the gases exhaled by coal has been neglected. The investigator soon becomes aware of the complexity of his task, however, and every new contribution to the literature on the subject is welcome. The United States Government started on such an investigation in 1907, under the supervision of Dr. J. A. Holmes, whose death we noticed a few months ago. In 1910 the Bureau of Mines took the matter over, and an account of the work has now appeared in Bulletin 72 of that Bureau, under the title "Occurrence of Explosive Gases in Coal-Mines," edited by W. H. Darton. As usual, the Bulletin, a pamphlet of 248 pages, embodies a summary of the European work on the subject, and this is all the more acceptable, as the extensive and very detailed, but not very deep, observations —if we may say so—hardly permit of drawing any novel general conclusions. We do not wish to be critical; we simply mean that the subject remains obscure, and will have to be attacked in other ways. It had been intended to ascertain especially whether there were any relations between the occurrence of gas and the structural and geological features of the coal-beds. There is no answer yet to that question. The fields of work selected were the northern anthracite basins of Pennsylvania, with more than 200 collieries, employing 64,000 men, in geologically much disturbed strata; and the southern part of the bituminous coal-fields of Illinois, where the beds lie nearly horizontal.

All coal, whether *in situ* or mined, exhales gas, either in blowers from accidentally opened crevices in which the gas has accumulated, or slowly from the solid coal, and this goes on for years. The quantity and composition of the gas vary very much. The ordinary yield is estimated at about 20 cub. ft. to the ton, so that a ton of coal, roughly occupying a volume of 20 cub. ft. or 25 cub. ft., would, on average, give an equal volume of gas at ordinary temperature and pressure. A ton of coal has yielded five times that average amount, and even 150 cub. ft. of mine gas; but such cases are rare. Yet there are many mines in the anthracite district of Pennsylvania from which more than 2000 cub. ft. of methane gas (the gas is practically methane there) escape every minute into the air at the mouth of the upcast. Powerful blowers may discharge many thousand cubic feet per minute, for minutes or hours, or for months; in many experimental galleries such gas from more quiet feeders has regularly been utilised for years for experimenting. The gas from a blower in Belgium, at a depth of 2000 ft., reversed the air current below and killed 121 people by an explo-

sion at the pit-mouth. Naturally-crushed coal is frequently rich in gas.

The chief constituent of the gas generally is methane (CH_4). The percentage of CH_4 varies between 0 and 99 and more; roughly 75 per cent. or more is, perhaps, the average. From three mines at Wilkes Barre, Pennsylvania, 9 million cub. ft. of methane are issuing daily, which would fill the gas-holders for a town of 300,000 inhabitants. It is believed that biochemical activity (bacilli) is partly responsible for the evolution of methane. Metamorphism (the heat of outbursts of igneous rock near the coal-seam) may also help to generate methane. But differences in the original plants, from which the coal was built up in the structure, and in the deposition of the coal are probably more important factors. As to the influence of geological features, and of the depth of the seam below the surface, little can be said, so far; that shallow layers are mostly poor in gas, and that all gas has generally gone from outcrop zones, is probably due to the fact that the gas can easily escape; the nature and permeability of the covering soil or rock is certainly important. The shales, sandstones, limestones, &c., above and between the coal-seams are themselves charged with gas, even if fairly impermeable, and may remain so after the removal of the coal. For this reason the filling up of the open spaces and roadways with refuse from dumps or with culm (slates, &c., from which the coal has been picked out) is not quite unobjectionable.

The yield of gas and of methane and the rate of evolution vary much in samples even from the same seam; they depend upon the size of the samples, *e.g.* In powdered coal the rate is higher than in big lumps; it does not make much difference on the whole, however, whether the experiments be made in a vacuum or at ordinary pressure. The surface exposed and the volume of the open spaces in the mines also count materially. In freshly exposed surfaces the rate is generally very high for a few hours; after a few days or weeks the rate may, or may not, become steady. In view of the influence of fresh exposures, experiments were first made in Saxony on the relative volumes of gas evolved on week days and during holidays, and observations were also made at 10 A.M. and 10 P.M. in collieries where there were no night shifts; the air was found relatively purer during the holidays, but day and night made no difference. More interesting are the observations taken during the long strike of 1912 in Pennsylvania and Illinois. In Pennsylvania considerably less methane was found in most cases during the strike than during corresponding periods of 1911 and 1910; but here were many exceptions which could not be accounted for. In experiments in Illinois, where the CO_2 and oxygen were determined in addition to the CH_4, the results were quite inconclusive.

As regards the gas pressure in the coal *in situ*, Lindsay Wood conducted the first extended investigations in 1880 in this country by boring holes, up to 47 ft. deep, into the working-face, and fitting into them tubes provided with gauges. The pressure rose gradually, and attained a maximum in from 2 to 16 days, after which it decreased; the maxima ranged from 28 lb. to 461 lb. per sq. in., the highest pressure observed in the Boldon mine being estimated at 84 per cent. of the pressure of a water column of the same height as the thickness of the cover over the seam. This colliery had only been opened eleven years, the others being much older. A pressure of 637 lb. per sq in. was subsequently found in Belgium; but these figures are exceptionally high. No pressure determinations were, unfortunately, made in Pennsylvania; in Illinois, where there is little mine-gas, though not absence of danger, the maximum recorded was 33 lb. per sq. in.

Most of the methane escaping is swept out by the ventilating air current; some of it remains in the air, and the percentage of methane varied, in 1883, in the Ruhr basin collieries between 0.002 and 1.4, whilst it never attained 1 per cent. in Silesian mines. These percentages again certainly change with the barometer, since more gas naturally escapes from the coal—at any rate from the exposed surface—at low air pressure than at high air pressure. That fact is well established, and is most regular in old workings with stationary conditions. But the often-asserted parallelity between low barometer and frequency of mine explosions does not exist, and can hardly be expected to exist, for several reasons. Many mine explosions are coal-dust explosions—not gas explosions—and in all of them the human factor and accidental features, electric sparks, faulty lamps and unsuitable blasting agents, failure of the ventilating plant, &c., play too important a part. Special caution in coal-mines during barometric depressions is, nevertheless, quite reasonable.

What we have said so far concerns chiefly methane. The other constituents of coal-mine gas have received less attention, because they are less feared, and because the conditions of their occurrence are more complex. These other constituents are carbon dioxide, oxygen, and nitrogen. Carbon monoxide is rarely found, and is probably a secondary product, due to explosions. Carbon dioxide is a regular constituent; blowers of it are common in the Rhenish district, and very probably connected with volcanism, and all coal regularly undergoes a slow oxidation by absorption of oxygen, resulting in the liberation of carbon dioxide. Hence its occurrence is interrelated with that of oxygen or air, and that complicates the inquiry. Up to 17 per cent. of CO_2 have been found in mine-gas near Zwickau and Bochum. In all mines considerable quantities of CO_2 are continuously exhaled by the men and animals at work, and the blasting operations add more CO_2 and other gases. Oxygen is constantly being absorbed by the men and animals and by the coal, and when the amount of oxygen and nitrogen in mine-air is determined, a deficiency of oxygen is generally found—that is to say, relatively less oxygen than in normal air. Over 90 per cent. of nitrogen has sometimes been credited to mine-gas; in rarer cases oxygen-blowers are spoken of. J. W. Thomas (1875) found up to 93 per cent. of oxygen in Welsh anthracite gas; but he heated the samples up to 212 deg. Fahr., as did Bedson and McConnell subsequently, who found 9.4 per cent. of oxygen, together with 16.6 per cent. of methane and 73 per cent. of nitrogen in some coal-dust. Treated similarly, one Silesian coal gave 60 per cent. of CO_2, 5 per cent. of oxygen, and no methane; and another, 94 per cent. of methane, 3 per cent. of CO_2, and no oxygen; but those figures are not comparable with the others we quoted. Hydrogen determinations have rarely been made, and argon and helium and the other rare gases are not mentioned at all in the Bulletin. This will be regretted by chemists and geologists. The enormous gas outburst at Neuengamme, near Hamburg, some years ago, was supposed to yield over 25,000 cub. m. of helium per year, and mine-blowers (at Frankenholz, Anzin, &c.) are often richer in rare gases than thermal springs. Moureu and Lepape pointed out in 1914 that in these two last-mentioned cases, and in other mine-gases as well, the helium was always accompanied by argon and the other rare gases, and that these gases could hardly have been produced in the coal, whilst helium would result from the decay of radium in the coal. Thus we might learn something as to the history of the coal from the study of the rare gases in mine-gas. This study of the rare inert gases would have to be carried on down below, whilst the laboratory seems to be the proper place for the phenomena concerning coal, oxygen, and carbon dioxide, which chemically react on one another. How curiously the permeability of rocks and coal may affect gas enclosures was observed by B. S. Randolph in a Maryland mine. The mine was partly flooded in 1894, and pumped dry again eighteen months later. In one spot the slate had not allowed the trapped air to escape, and the water never reached the roof though under a head of more than 80 ft. of water; in another spot the entrapped air, under a head of 40 ft. of water, seemed to have forced an outlet through 200 ft. of coal.

THE LIFE OF CONCRETE STRUCTURES.

ALTHOUGH instances are known of concrete made by empirical means having withstood the ravages of time for over 2000 years, we have little or no knowledge of the failures which must have occurred in this material, and are therefore apt to credit the ancients with greater skill than they actually possessed. There is no doubt that a modern structure properly designed and executed in concrete or ferro-concrete would last at least as long as the mighty structures of antiquity if this were desirable; our modern needs, however, are such that the lives of structures are reckoned in decades rather than in centuries. Nevertheless it is important to consider the various factors affecting the life of such structures, and this was done in an interesting paper presented by Mr. Bertram Blount at a meeting of the International Engineering Congress in San Francisco, in September last.

Bad cement, one of the possible causes of premature destruction, need not be considered at length, because cement free from any inherent fault is certainly to be obtained. The aggregate, however, is a fruitful source of trouble, since local material of the most diverse description must always be used. It is essential that the material should be chemically stable under the conditions in which it is employed, and, for this reason, rocks containing pyrites should, in general, be avoided. The amount and size of the enclosed pyrites should, however, be considered, as a granite or hard limestone containing merely specks of pyrites would give perfectly satisfactory results. Slags may also be used if their silica content is high enough, the best criterion of their suitability being their behaviour during exposure to the weather on a slag heap. Substances containing sulphates and sulphides capable of oxidation under working conditions are dangerous and should not be employed; but, in Mr. Blount's opinion, there is no more dangerous aggregate than coke breeze. This is due to the fact that some samples contain a large proportion of sulphates, which, on account of the porosity of the breeze, are readily extracted and brought into contact with the cement. Mechanical defects such as softness, cracks, or excessive smoothness in aggregates are easily detected and avoided, and bad proportions, bad mixing, bad workmanship, and bad design call for little comment.

External causes, such as violent storms, earthquakes, and other so-called "acts of God," may destroy the best of structures, and fire is another uncontrollable destructive agent. Concrete structures, though not of themselves inflammable, are seriously weakened by fire owing to the fact that the combined water and carbonic acid are expelled from the concrete at a comparatively moderate temperature. The deterioration, however, is less than would be expected, and Mr. Blount's experiments with a 3 to 1 mortar, proportioned by weight, show that there is no appreciable effect up to 500 deg. Cent.; even at 1100 deg. Cent. the specimens were still sound, though very weak. In this respect the most vulnerable part of a ferro-concrete structure is the steel reinforcement, and if the heat penetrates sufficiently to soften this, the structure will inevitably collapse.

The destruction of concrete by sea-water has been a serious consideration ever since Portland cement came into use. In Mr. Blount's opinion denseness and imperviousness, and therefore the liberal use of cement, are essential to ensure longevity in concrete exposed to the action of sea-water. He also recommends that any good form of puzzolanic material, such as trass, should be used, when it is available, to replace part of the sand. This material forms a calcium silicate with the lime liberated during the setting of Portland cement, and helps to render the concrete more impervious. Added materials, such as barium salts, soap, and oils, although valuable in certain circumstances, are considered by Mr. Blount to be unsuitable for heavy sea work, for which there is nothing better than ordinary concrete made with an ample proportion of cement, with a carefully chosen and graded aggregate, and with the addition of trass if local conditions allow; such concrete, he considers, should last indefinitely, or certainly until the work had become obsolete. Many putrescent matters have a very deleterious effect upon concrete. Sewage, for instance, gives off gases containing sulphur, and these, under suitable conditions, will oxidise and produce sulphuric acid or sulphates, which injure or destroy the cement they come into contact with. Electrolysis by stray currents is another destructive agent, the real remedy for which is in the hands of electrical engineers, since the stray currents should be kept in their proper channels. In some cases, however, it may be well worth while to provide the concrete with a protective sheath of asphaltic material.

All the causes of shortened life which have been mentioned above in connection with ordinary concrete apply with equal or even greater force to reinforced concrete, and there are some other causes peculiar to this method of construction alone. It is an extremely fortunate circumstance that iron does not corrode in an alkaline medium such as cement is, but this is only true as long as

the iron is completely enclosed with concrete which is fully in contact with it, and if the concrete is free from fissures. It is also most desirable that the concrete should be impervious; hence the necessity for employing a mixture rich in cement. Moisture left in the concrete after its preparation, or any stationary water, is of little consequence, because the water becomes saturated with lime, and forms an alkaline medium, which preserves the steel. Continued access of water, involving anything in the nature of a flow, will remove this preservative, and the usual corrosion of steel in water will commence. Another fortuitous circumstance in connection with reinforced concrete is that the coefficients of expansion of steel and concrete are not very different, so that the stresses due to unequal expansion are small. The stresses due to the joint expansion of the two materials may, however, be considerable if resisted, and should certainly be calculated for structures exposed to a large range of temperature. Mr. Blount also points out that serious stresses may arise from the alterations in the dimensions of concrete which accompany changes in its wetness or dryness, and occur particularly in the case of reinforced-concrete dams. Experimental investigation of this characteristic certainly appears to be desirable. Further data of the rate of percolation and alteration of strength of reinforced concrete, and of the corrosion of steel in concrete, would also be welcomed.

Our present knowledge, Mr. Blount concludes, is such that it can safely be said that there is no fear of the corrosion of steel reinforcement when it is well embedded in good non-pervious concrete of adequate thickness, even when the concrete is exposed to the action of sea-water or other saline solutions. The same, however, cannot be said when the concrete is exposed to electrolysis. Cases of the destruction of ordinary concrete by electrolysis have been observed, but the risk is very much greater with reinforced concrete. The advantage of an alkaline medium may disappear, and the reinforcement, serving as a positive electrode, may be attacked by the negative ions of the electrolyte. Corrosion will be rapid, and further damage will arise from the stresses exerted by the rusting iron. These are known to be large, though they have never been computed. In a modern structure, with its numerous electric leads, most serious results may arise from current leakage, and the mischief, being wrought secretly and effectively, may quite nullify any reasonable presumption as to the life of the structure. It is true that but few cases of this trouble have yet been recorded; but, in Mr. Blount's opinion, they will become fairly common, and he gives electrolysis third place in the list of destructive agents arranged in order of sinister magnitude. Corrosion by saline solutions takes first place on the list, and the permanence of structures exposed to this risk depends almost entirely on the impermeability of the concrete. Aggregates of the coke-breeze class, containing sulphates, or potential sulphates, take second place, and here again the trouble is largely due to the fact that the concrete cannot be impervious. If water reaches one of the surfaces of the concrete, it will speedily find its way into the interior, and where water can go air can follow, so that the sulphides are in a favourable condition to become sulphates, and the fate of the structure is then settled.

A perusal of the foregoing matter may have given the reader the impression that concrete structures are so liable to decay as to be almost ephemeral. This is because only the faults and vices of cement have been dealt with; its virtues have been ignored. It must also be borne in mind, as Mr. Blount points out in his conclusion, that all the causes of destruction, except external violence, can be controlled, and their effects nullified by knowledge, care, and skill exercised along the lines mentioned above; security and something like complete permanence will then be attained.

THE GERMAN ELECTRICAL INDUSTRY.

THE exceptional and important place which the electrical industry occupies in Germany is frequently enlarged upon, and is possessed of considerable interest. As a sign of the leading position it boasts, it may be mentioned that the hands employed in this branch are among those earning the highest wages, and a wage of about 1 mark per hour is by no means of rare occurrence, while the pay is almost continuously rising. Another distinctive feature is the great number of officials, both in the technical and the commercial departments. The profits of the business are influenced by the keen home competition, as well as the competition on the world's market. In this connection it may be mentioned that during the five years 1907-8 to 1911-12 the annual revenue of forty-five firms in the electro-technical industry, reckoned as per cent. of the share capital and the genuine reserves, receded from 8.70 to 7.74 per cent., whereas the revenue of the electricity works, if they were limited companies (89 works), during the same period rose from 8.50 to 9.99 per cent. The aggregate dividends of the share capital in the two branches naturally show a similar, though not so pronounced, movement. The following table contains some interesting statistics for the year 1911-12 about the electrical concerns as against the total of German limited companies:—

—	All Companies.	Electro-Technical Industry.	Electricity Works.
Number of companies ..	4712	45	89
	marks	marks	marks
Share capital entitled to dividends	14,550,281,000	231,995,000	689,863 000
Genuine reserves ..	3,515,432,000	45,101,000	120,054,000
Total capital ..	18,065,713,000	277,096,000	809,917,000
Debentures	3,499,947,000	90,181,000	469,512,000
Hypothecated	1,438,984,000	6,020,000	18,387,000
Annual revenue	1,470,520,000	21,450,000	80,934,000
Aggregate dividends ..	1,220,930,000	17,378,000	63,005,000

The following table shows the continuous increase in the number of concerns and hands employed in the "fine mechanics" and electro-technical branches:—

Year.	Number of Concerns.	Increase per Year in per Cent.	Insured Full Hands.		Wages.	
			Total Number.	Increase and Decrease per Year in per Cent.	Aggregate.	Average Wage per Hand.
					marks	marks
1898	1652	—	46,555	—	50,703,000	1089 10
1899	1825	10.5	54,928	17.9	60,890,000	1108.54
1900	2017	10.5	61,578	12.1	68,964,600	1119.98
1901	2168	7.5	59,010	— 4.2	69,503,000	1177.82
1902	2261	4.3	53,809	— 8.8	63,839,000	1186.40
1903	2331	3.1	60,006	11.4	71,362,000	1189.26
1904	2481	6 4	68.385	14.0	82,169,000	1201.56
1905	2718	7.6	82,510	20.3	102,264,000	1239.41
19.6	2982	9.7	94,472	14.5	121,352,000	1284.53
1907	3241	8 7	100,966	10.7	146,919,000	1455.13
19 8	3475	7.2	108.472	7.4	158,516,000	1461.35
1909	3777	8.7	119,395	10.1	172,836,000	1447.60
19 0	4101	8.6	142,585	19.4	212,115,000	1488.15
1911	4587	11.9	169,123	18.7	254,670,000	1506.33
1912	5082	11.7	192,714	13.9	298,348,000	1548.14

The total figure for workmen in 1912 comprises 9655 workmen employed at electricity works, and 43,587 hands employed in installations, &c., leaving about 138,000 hands for the actual manufacturing industry. From the year 1900 to 1912 the average wage per hand (male and female) per annum has thus risen from 1120 marks to 1548 marks, or about 40 per cent.

Compared with other leading industries, the electrical industry shows decidedly the greatest amount of development. From the official industrial statistics for 1895 and 1907, it appears that the aggregate industry, including the mining and building industries, showed an aggregate decrease in the number of concerns, principally through amalgamations, of 4 per cent., and an average increase of hands employed of 37 per cent. The electrical industry, taken separately, on the other hand, showed an increase of concerns of 315 per cent., and an increase in the number of hands employed of 411 per cent. Leaving out the electricity works, the figures are respectively 225 and 385 per cent., whilst the corresponding figures for the branch which comes next, machinery and apparatus, are only respectively 57 and 102 per cent. The development as regards mining, iron industry, and salines, amounted to 60 per cent. as regards number of hands employed, whereas the number of concerns had receded 3 per cent. Also the chemical industry showed a decrease in the number of concerns of 4 per cent., whilst that of employed hands rose 51 per cent.

The industrial statistics for the years 1901 and 1911 likewise show a decided development of the electrical industry. Taking the aggregate industry, and gauging the development through the insured hands of sixty-six trade unions and their aggregate wages, during this decade there was an increase as regards the former of 43 per cent., and as regards the latter of about 80 per cent. The electrical industry, however, boasts the imposing corresponding figures of, respectively, 187 and 266 per cent. This means a development between three and fourfold that of all the other industries. Next come the machinery and "small-iron" industry, with respectively 61 and 99 per cent., and the chemical industry, with respectively 50 and 89 per cent. In Berlin, the number of hands employed in the electrical industry is exceptionally large, according to figures for 1913, about 25 per cent. of the aggregate, or 107,152 hands out of a total of 437,555. British engineers who have had to meet German competition here and in the neutral markets will have no difficulty in accepting the statistics.

NOTES.

THE PATENT JOURNAL.

THE *Illustrated Official Journal (Patents)* to be issued on the 12th inst. will contain a certain rearrangement of matter which has been adopted for convenience of reference. Heretofore the list of applications has appeared in numerical order; it is now proposed to arrange the list of applications alphabetically under the names of the applicants and communicators, the latter being printed in italic type. When an application is filed in more than one name, each name will be given independently. After the name and subject entry, which latter is an abridgment of the title, there will appear a number which will be that of the application. This number is to be used for correspondence purposes only up to the date of acceptance of the complete specification. When the complete specification is accepted, or becomes open to public inspection before acceptance, a new number will be given to the application, and this number must be used in all proceedings after acceptance. That is to say, an application will receive what may be termed a "serial" number, and on acceptance of the complete specification, the application will receive what may be called a "patent" number. This new procedure is really an adaptation of the American system. The alteration in numbering has been adopted in order to render it possible to publish abridgments of specifications very much earlier than is now the case. Under the present practice, the abridgment of a specification does not appear until some fifteen months after the date of application, even if the complete specification has been printed and on sale for many months. With the new system of numbering, it will be possible to publish the abridgments some few weeks after the complete specification has been accepted, so that they will be available for searching purposes at an early date. The new system will have its advantages and disadvantages, but the advantages will probably outweigh the disadvantages. It will be impossible with the new system of numbering to gain an idea from the number as to the year in which an invention was applied for. It is proposed that the new numbers shall start with the number 100,001. This number has evidently been adopted so as to prevent confusion, as under the old system each year started with a specification numbered 1, which was distinguished from other specifications of like number by the addition of the year. It would obviously be inconvenient to start again with the numeral 1 without the index year. The new system will eventually result in a large saving in cost of printing to the Patent Office, and this is, no doubt, one reason why the matter has been taken in hand. The revised system has been under consideration to our knowledge for several years, but the present cry for economy has no doubt caused the wheels of the department to move.

THE SUPPLY OF PETROL.

The dearth of fuel for internal-combustion engines was considered a grave problem already a few years ago, when the demands for the Army and Navy were considered, and when it was hardly foreseen how enormously a war would increase those demands. The point then accentuated was that substitutes for petrol would have to be found, that alcohol could be utilised, and that everything possible should be done to initiate and develop the production of alcohol from materials and by

processes best suited to the respective district or country. The petrol question is now acute. If little is heard, however, at present about alcohol, the reason is not merely that wartime is not propitious to the creation of new industries. Petroleum-cracking has quietly been pushed, and the conviction is gaining ground that no serious shortage of petrol or gasolene will inconvenience the automobile trade as long as petroleum, even of the heavier grades only, is produced in anything like the quantity now being brought forth in various parts of the world. At first glance this view may appear optimistic. For some of the old oil-fields are undoubtedly giving out, or not increasing their output, and the new fields being opened up, in Mexico, California, and elsewhere, mostly yield oils which contain little or no gasolene. On the other hand, the manufacture of automobile vehicles has taken astounding strides. In the United States some 350,000 motor vehicles were registered in 1910; 550,000 in 1911; 990,770 in 1912; 1,808,000 in 1914; and by August, 1915, the 2,000,000 figure was probably exceeded. Statistics from the countries engaged in the war are hardly available, but great increases may be assumed. Extraordinary efforts had to be made, and are being made, to meet the full demand; and though little is allowed to leak out, various cracking processes are technically being applied with more or less success. What we have been able to notice in our columns has mostly been of the experimental research type, and secrecy is more than ever the rule during the war. An instructive review on "The Cracking and Distillation of Petroleum under Pressure," by Dr. B. T. Brooks, of the Mellon Institute for Industrial Research, University of Pittsburg, appeared in the December issue of the Journal of the Franklin Institute. It is rather a compilation of notes on various features, not profitably to be discussed without entering into detail, than a general review; but it shows that a good deal is possible and is being done. The very unpleasant odour of cracked petrol, often ascribed to the presence of olefines, is attributed by Brooks to the presence of impurities—notably, naphthenic acids, sulphur compounds, and also pyridene bodies (nitrogen compounds); treatment with alkaline plumbite, desulphurising by means of copper oxide, and treatment with metallic sodium, in particular, are remedies. Since sodium does not attack olefines, which when pure have a pleasant smell, moreover—just as carbon disulphide has, though the commercial article smells vilely—the olefines are not likely to be responsible; on the other hand, it must be acknowledged that the olefines are apt to acquire an objectionable smell when exposed to the atmosphere. It is interesting to note that modern processes go back rather to the work of Engler and others of fifteen years ago, than to the later researches of Sabatier on hydrogenation by the aid of catalytic agents, which have not proved very successful in practice. Brooks questions whether hydrogen is split up from certain compounds and then taken up by the unsaturated hydrocarbons; he also doubts with A. Hall (see ENGINEERING, February 26, 1915, page 250) that the hydrogen generated by passing steam over red-hot alumina, coal, iron, &c., can be utilised. The one great trouble of most cracking processes, the deposition of coke, can at any rate be mitigated by the use of mechanical stirrers. It would be far too early yet, even if secrecy were not maintained, to speak of any type of particularly promising cracking processes. But cracking can help very materially, though the other motor fuel resources, alcohol, shale oil, condensation of natural gas, and benzol recovery from coke-oven gas, should certainly not be neglected.

THE COMMERCIAL-MOTOR USERS' ASSOCIATION (INCORPORATED).—This Association has been seriously considering the steps to be taken to meet the very serious shortage of commercial-motor drivers. A deputation was received by the Reserved Occupations Committee of the Board of Trade on the matter, when the Association urged that all remaining heavy-motor-car drivers should be placed on the "Reserved" list. Its efforts were successful, and an official announcement has now been made that carters, lorrymen, and draymen (horse and power), not delivering to private houses, have been placed on the list of "Reserved Occupations." In addition, the Association has approached the Local Government Board to reduce the minimum age for the holding of motor-car driving licences, subject to satisfactory safeguards, and so increase the number of available drivers for civilian transport purposes.

LITERATURE.

The Rare-Earth Industry, including the Manufacture of Incandescent Mantles, Pyrophoric Alloys, and Electric Glow-Lamps. By SYDNEY I. JOHNSTONE, B.Sc. *Together with a Chapter on the Industry of Radioactive Substances.* By ALEXANDER S. RUSSELL, M.A. D.Sc. London: Crosby Lockwood and Son. [Price 7s. 6d. net.]

THIS work is one of a series of manuals of chemical technology, edited by Dr. Geoffrey Martin, and taken in connection with the appearance of other technical works, indicates a revived interest in the more obscure chemical processes over which the virility and range of German research have acquired an undisputed prominence. The collected results are eminently interesting, since they manifest the industrial importance attaching to certain rare rocks and minerals, and demonstrate an orderly and sustained progress from the triumphs won in the laboratory to the successful exploitation in the wider fields of manufacture and commerce. The term "rare earths" as here employed, the author reminds us, is a misnomer. The nomenclature, recalling the times when chemists were acquainted with only small quantities of certain minerals which figured as curiosities, has remained, but metals and elements allied to the groups of cerium and yttrium earths are now measured by the ton, and a revised terminology becomes necessary with the enlarged sphere of utility. The author includes the oxides of thorium and zirconium with the "rare earths," and then proceeds to add such elements as tantalum and tungsten, finally finding it convenient to embrace in his description uranium and vanadium, a course he considers warranted by reason of a short excursion into the industry of radioactive materials. Such a grouping permits a survey of several interesting trades, makes readily available much information, while at the same time the current literature and specification of patents, where more precise details may be found, are indicated. At a time when the achievements of German research are being so extensively applauded, and our want of enterprise and initiative as loudly condemned, such a book is welcome, as it may tend to promote a better sense of proportion and an increased respect for our own moderate endeavours.

The plan of the book is simple. The literature connected with the industries in which each of the substances, as thorium, titanium, &c., enters, is quoted with some attempt at completeness; then follows the method of the metal's occurrence in Nature and the geographical distribution, with ample statistics concerning the sources and value of supply. The method of deriving the mineral from the crude deposit is next described, and, finally, an account is given of the industrial utilisation of the product. The statistics supplied are very useful and instructive in showing the course of development of a particular industry, and enable us to estimate its relative importance. To select thorium as an illustration, we find that when Welsbach invented the incandescent mantle for gas-lighting, or employed thorium nitrate in its construction, the sources from which thoria could be derived were small, and confined to Scandinavia. The price then ranged round 100*l*. per kilogramme, and the desire to share this monopoly led to greater activity on the part of prospectors, resulting in the discovery of the monazite sands of Brazil, a weathered rock, concentrated by tidal action, which, with phosphate of the cerium and lanthanum earths, contains a small and variable percentage of thoria. For many years the Brazilian monazite formed the main source of all the thoria of commerce, and is still the largest contributor, though for a while deposits in Carolina, U.S.A., competed with those of Brazil. The price of thorium nitrate fell, however, the Carolina mines proved unremunerative, and America retired from the competition. Next Southern India and Ceylon were found to possess a monazite containing nearly twice as much thoria as the Brazilian sands, with the result that the output fell from 6462 metric tons in 1909 to 1437 tons in 1913. It is not to our credit that the whole of the Travancore monazite, amounting to over 1000 tons per annum, has for several years past gone to Germany, from whom we imported in 1913 mantles to the value of 302,000*l*. It might seem that the impossibility of importing the raw material would occasion some inconvenience to Germany; but it is necessary to remember that a single kilogramme of thorium nitrate, valued at 18*s*. before the war, is sufficient to produce 1200 mantles of the cheap German type. The total consumption of incandescent mantles is estimated at 222 millions annually, and these large figures show that the industry is deserving of study. If any other proof were needed, it would be found in the voluminous patent literature to which reference is here made.

The processes through which any raw material of slight concentration passes from mining to its final utilisation in the arts or industries are so numerous that exhaustive treatment is impossible. It is a little annoying to find the technique indicated rather than pursued, though we readily admit that in a book of this size, treating of many necessarily involved processes, judicious curtailment is of the first importance. To excite the curiosity of the layman, rather than satisfy the demands of the expert, seems to be the object of the author. This course may be inevitable, for in several processes here mentioned, where small quantities of material of great purity have to be derived from large masses, individual treatment, or so-called trade secrets, must operate. After making every allowance for these difficulties, one is tempted to ask what real purpose is served by these compilations. The expert intending to apply the lines here indicated to commercial purposes would be compelled to go to the original authority for his information, and those who are intelligently interested in the final outcome of complicated processes can be catered for more simply.

Looked at broadly, the rare earths, to each of which the author devotes a section, are the sources of metals that are used in two directions, either in the construction of filaments of electric glow-lamps or for imparting peculiar qualities, as ductility and hardness, to steel. It is true that some have been used as mordants in dyeing, and that others, which in the form of pyrophoric alloys have been used as scientific toys, may find a gruesome usefulness in warfare by indicating the path of shells and assisting the manipulators of anti-aircraft guns. These, however, are simply by-products, and the two main industries that make this kind of study desirable are the manufacture of steel and of incandescent lamps. Zirconium, the product of the Brazilian baddeleyite, stands on a different footing. Owing to its very low coefficient of expansion over a large range of temperature, it is of great service in the manufacture of crucibles and vessels of a refractory nature that have to be subjected to great or sudden changes of heat. Vessels formed of zirconia, while white hot, can be plunged into cold water without risk of fracture. Niobium, often found associated with tantalum ores, is a scientific curiosity for which no commercial use has been found either for the metal or its salts.

Tantalum, on the other hand, finds a fairly wide range of utility. At present it is best known as a suitable material for making the filaments of incandescent electric lamps, but the demand for the ores is small, and the Australian mines which furnish the bulk of the crude ore have been little worked of recent years.

Tungsten, now in greater demand than tantalum for electric lamp filaments, has found a wide use in the steel industry for imparting hardness and toughness to steel used in armour-plates, projectiles, and fire-arms. It is a constituent in many interesting alloys, and if the cost of production could be reduced, it would, no doubt, find a wide field of utility. It is stated that the cost of production per ton of metal amounts to 80*l*., so that, if ore containing 60 per cent. of tungsten oxide costs 100*l*. per ton, the cost of the pure metal is 310*l*. per ton.

The employment of these two elements in electric lamps warrants the author in inserting a chapter on the glow-lamp industry. The history of the displacement of the carbon filament, with an efficiency of 3 watts per candle-power, by metals having a high melting point and an efficiency of 0.5 watt per candle-power, is well and accurately traced, and will be found an interesting chapter in the economics of illumination. The vertical osmium lamp, with its sagging filaments and frequent fracture, is seen to give way to the tantalum of drawn wire, with the familiar "spider" device to increase the length of the wire. The part played by the "squirting" filament of tungsten and many of the ingenious devices that have been proposed and patented find their merits recognised here, concluding with a special word of approval for the tungsten filament enclosed in a nitrogen-filled bulb; there is, however, no mention of neon, which is coming into favour in connection with illuminants.

Vanadium, found in many minerals of fairly common occurrence, like tungsten, is utilised mainly in the steel industry. A ferro-alloy, with a low percentage of carbon, is capable of toughening steel, and finds application alike in the manufacture of chrome, manganese, open-hearth, and high-speed tool-steels. The method of extraction of vanadium from its ores, and of the separation of the metal from other mineral substances which are dissolved at the same time, is well explained.

Uranium, together with the paper on radioactive substances, by Dr. Alexander Russell, is somewhat out of place here. Uranium ores can be classed among rare earths only in connection with radium. The geographical distribution of pitch-blende and carnotite, the sources of uranium, is wide; but since the value of these substances depends mainly on the radium content, the price of ore containing 2 per cent. of uranium oxide ranges round 30*l*. The price of radium is quoted here at about 24*l*. per milligram of radium element, though no radium is sold in the metallic form. On that basis, a milligram of radium chloride should cost about 18*l*. 10s., and a similar quantity of anhydrous bromide 14*l*. Yet the price of radium bromide in 1902 was only 5s. per milligram. Such a rapid rise in price is difficult to explain. Professor Rutherford has stated that the present price of radium is very high, and bears no relation to the cost of separation of the radium from uranium minerals. "The present price is artificial. There seems to be no reason why the present abnormally high prices of radium should be ultimately maintained." The processes of separation as described here appear tedious and costly, but insufficient to explain the great rise in price during the last dozen years. Professor Rutherford's contention seems well founded, even leaving out of consideration the effect that the competition with mesothorium may bring about.

BOOKS RECEIVED.

Business Prospects Year-Book 1916. Edited by JOSEPH DAVIES and C. P. HAILEY. Cardiff: The Business Statistics Company, Limited. [Price 10s. 6d. net.]

The Colliery Manager's Pocket-Book, Almanack and Diary for the Year 1916. Edited by HUBERT GREENWELL, F.S.S., Assoc. M.I.M.E. London: The Colliery Guardian Company, Limited. [Price 2s. net.]

The Guide to South and East Africa for the Use of Tourists, Sportsmen, Invalids and Settlers. Edited annually by A. SAMLER BROWN, F.R.M.S., and G. GORDON BROWN, F.R.G.S. 1916 Edition. London: Sampson Low, Marston and Co., Limited. [Price 1s.]

United States Geological Survey. Bulletins. No. 544: *Fauna of the Wewoka Formation of Oklahoma.* By GEORGE H. GIRTY. No. 566: *Results of Spirit-Levelling in Utah*, 1897-1914, *inclusive.* By R. B. MARSHALL. No. 569. *Results of Spirit-Levelling in Iowa*, 1896-1913, *inclusive.* By R. B. MARSHALL. No. 587: *Geology and Mineral Resources of Kenai Peninsula, Alaska.* By G. C. MARTIN, B. L. JOHNSON and U. S. GRANT. No. 601: *Geology and Mineral Deposits of the National Mining District, Nevada.* By WALDEMAR LINDGREN. No. 612: *Guide-Book of the Western United States.* Part B: *The Overland Route, with a Side Trip to Yellowstone Park.* By WILLIS T. LEE, RALPH W. STONE, HOYT S. GALE and OTHERS. Washington: Government Printing Office.

A Treatise on Safety Engineering, as Applied to Scaffolds. Hartford, Conn., U.S.A.: The Travellers' Insurance Company. [Price 3 dols.]

NAVAL RECRUITING.—There is still an opportunity for men to signify their willingness to enter the Navy or Royal Marines, and to defer their actual service, by taking advantage of the naval group system. Recruits under this scheme are transferred to the Royal Naval Volunteer Reserve, Section Y, or the Royal Marine Volunteer Reserve in one of four groups—two for single men and two for married men—the dividing age between the two groups being in each case 30. In view of the fact that no appeal to be placed in a later group can be allowed, men who are not prepared to serve fourteen days after being called up cannot be accepted (*i.e.*, no starred or badged men can take advantage of the scheme). Men presenting themselves must be between the ages of 18 to 40, and must be physically fit. The scheme covers the ordinary ratings of the Royal Navy, the Royal Marines, and the Royal Naval Division. The ratings of writer and ship's steward's assistant have been closed, and there are only a few vacancies for carpenters. There is a wide choice of occupation offered to men with some special training, but those ratings which the Navy particularly needs at the moment are those of ordinary seaman and stoker, which require no previous training. Skilled men are also needed for service as electrical and engine-room artificers. Full information with regard to entry into the Navy and the Royal Marines may be obtained from any post office, labour exchange or coastguard station, or from the Admiralty Recruiting Office for the Royal Marines and Royal Navy in Great Scotland Yard. The London recruiting office for the Royal Naval Division is at 112, Strand, W.C.

HONOURS FOR ENGINEERS.

THE New Year Honours' List is naturally confined almost exclusively to the recognition of the services, direct or indirect, concerned with the war, and since engineers have played a large part, not only in the actual operations in the field, but in the preparation of war material, it follows that many of them are entitled to distinction. For this reason there are more engineers in the list than has been the case in former years, and we hope that this is a promise of a much more extended acknowledgment than has been made in the past of the great services rendered by members of the profession.

Engineers of all classes will be particularly pleased that Mr. George N. Barnes and Mr. William Crooks are both to be sworn of His Majesty's Most Honourable Privy Council. Both, as is well known, have long been identified with trade unions, the former having been assistant secretary to the Amalgamated Society of Engineers from 1892 to 1895, the general secretary from the latter year until 1908. He sits in the present Parliament as a member for one of the divisions of Glasgow. Mr. Crooks has not had the same official connection with the unions, but he has been closely associated with many of the labour movements of recent years, and has done much useful work in the East End of London, as Mayor of Poplar, as a member of the London County Council, and since 1903 as a Member of Parliament for Woolwich. Both gentlemen have taken a sane view of the labour situation since the outbreak of war, and if all connected with labour had been as active and sincere patriotic no difficulties such as now beset the Ministry of Munitions would have arisen. Mr. Crooks has made more than one visit to our troops in the trenches.

Upon Lord Mersey there has been conferred the dignity of a viscounty of the United Kingdom, in recognition of his service in connection with the investigations of the losses of ships. Amongst the six new barons is Lord Charles Beresford, a vigorous advocate of naval strength, and Mr. D. A. Thomas, the managing director of the Cambrian Combine and other large colliery companies.

A baronetcy of the United Kingdom has been conferred upon Mr. A. F. Yarrow, whose inventive genius, displayed in several departments of engineering, has had a great influence on the attainment of that increased speed in warships which has been such an important factor in the achievement of our naval successes and in the continuance of our complete supremacy at sea. A similar honour has been conferred upon Sir George Bullough, of the engineering firm of Messrs. Howard and Bullough; and upon Mr. A. A. Booth, the chairman of the Cunard Company and one of the most prominent shipping authorities in this country.

Amongst the new knights we note the names of Mr. Francis Henry Dent, general manager of the South-Eastern and Chatham Railway, which has dealt with a large volume of traffic arising from the movement of troops, munitions and stores during the whole period of the war; and Mr. John Howard, engineer and builder of the Palace Pier at Brighton.

The promotions and appointments to the Most Honourable Order of the Bath are much more numerous than usual, particularly in the Military Division, in recognition of distinguished services in the Navy and Army. We are glad to note that a Companionship of the Bath in the Military Division has been conferred upon Engineer-Captain William Whittingham, R.N., Engineer-Captain Henry Humphreys, R.N., and Engineer-Commander George Edward Andrew, R.N.; while a Companionship of the Bath in the Civil Division has been conferred upon Rear-Admiral William Henry Riley, and a Knight-Commandership of the Bath in the Civil Division upon Colonel H. C. L. Holden, Assistant Director of Supplies and Transport at the War Office.

In the Colonial List, Mr. Collingwood Schreiber, General Consulting Engineer to the Government of Canada, has been promoted from Companion to Knight-Commander of the Most Distinguished Order of St. Michael and St. George, while the new Companions include Mr. Thomas Inglis Binnie, Director of Public Works in the Nyassaland Protectorate, and Mr. John Cadman, D.Sc., Professor of Mining in the University of Birmingham, Petroleum Adviser to the Colonial Office, and Coal-Mining Adviser to the Government of Nigeria. Mr. John Kennedy, Consulting Engineer to the Montreal Harbour Committee, has been made a Knight Bachelor; as also Mr. William Wilson Hoy, General Manager of Railways and Harbours in the Union of South Africa.

In the Indian List, a Companionship of the Indian Empire has been conferred upon Mr. J. Norman Taylor, of the Public Works Department, Officiating Superintending Engineer in the Irrigation Branch, Upper Jhelum Canal, Punjab; while a Kaisar-i-Hind gold medal has been awarded to Mr. Walter Samuel Sharpe, Superintendent of Telegraph Engineering in the Bombay Division, and to Mr. Henry James Heamey Glenn, Executive Engineer in the Province of Delhi.

SHELLS; MORE SHELLS.

TO THE EDITOR OF ENGINEERING.

SIR,—May I reply briefly to the letter which, headed as above, appears in your issue of the 17th inst.? I am, of course, strongly in favour of any correct procedure which will help us to bring the war to an early and victorious close. Some of the statements in the letter referred to, however, seem to me to be so vague and uncertain that I should like to correct them. For instance, an analysis of forged steel is given "under correction," and consequently the words added—"made from the usual mild steels, hence their inferior splintering properties"—can have no definite meaning.

Shell steel is, of course, made to stringent Government specification, and is certainly not of the composition given in the letter. Moreover, it must be sound, free from blow-holes and segregation, and these conditions are obviously more difficult to attain in cast and malleable iron. Should there be a flaw of any sort in the material, there is a risk of premature bursting, which is highly dangerous. The letter also appears somewhat contradictory; for instance, it is stated that under internal stress the material suggested is stronger than forged steel. The qualifying note, that when it does break up, it does so "in strips and streaks," does not alter the claim that more force is required to break it, and consequently, assuming the statement to be correct, one might ask, Is it any advantage? Other advocates of cast shells have suggested that the reverse is to be preferred, and is naturally given by cast iron. I am, and have been for many years, closely interested in, and connected with, cast and malleable iron; but while suitable steel is obtainable, I do not see any advantage in changing.

After all, the supply of finished shells must really be regulated by the amount of explosives available for filling them.

This, I think, is the real crux of the whole matter.

Yours truly,
E. WHEELER.

Higher Openshaw, Manchester, December 29, 1915.

TO THE EDITOR OF ENGINEERING.

SIR,—I have read with considerable interest Mr. Keith's remarks on "Shells; More Shells" in your valuable paper of the 17th ult., and have come to the conclusion that it is possible something more might be done, as suggested by him, in the production of cast-iron shells in larger quantities. At the same time it is to be regretted that Mr. Keith has evidently something in reserve in this matter which obviously cannot be put into print, which, I assume, will be on account of valuable information leaking out to the Germans.

Reading between the lines, I have the opinion that Mr. Keith has an idea that metal can be cast and dealt with in a similar way to the ordinary cast iron (malleable castings), and shells could be so produced as could readily take the place of high-explosive, high-velocity shells. It is, however, to be regretted that Mr. Keith is unable to mention the name of the inventor of these shells, so that the matter could be properly discussed and brought to the notice of the Minister of Munitions. Surely if this inventor referred to is capable of making a metal to give high tensile strength and high resistance, with guaranteed splintering properties, as mentioned by him, the matter is worth the consideration of the Ministry of Munitions.

Furthermore, I was very interested in Mr. Keith's preliminary work in cast-iron shells, where he referred to ordinary cast iron, and I regret to notice that his efforts seem to have been reduced in connection with this.

For example, I think it will be well understood that low-velocity trench guns are gradually finding a very important place in trench warfare, and in this respect it is obvious that cast iron could be cast in a shell of a very large diameter, which could be thrown a short distance with a very light gun. For this purpose a metal could be made, say, with a maximum of 0.45 per cent. phosphorus, giving a very close-grained metal, which when slightly annealed would burst with great efficiency and destruction. If such a shell were introduced, roughly speaking, at least double the present quantity of shell-castings could be made with the raw materials of this country alone; and from what I have seen and heard something like this must be done unless we are prepared to sacrifice many valuable lives and the integrity of Great Britain.

During this war the Germans have led the way in many respects by the introduction of science into their trench warfare—such, for example, as by the use of gas and the machine-gun. It is to be hoped that the next success in this direction will be achieved by Great Britain.

I might say that I, like Mr. Keith, have a good deal of information concerning this matter, which for the time being I cannot divulge, and which I feel confident could be usefully employed, assuming that the Ministry of Munitions organises the use of our raw materials on strict economical lines.

Yours truly,
FREDERICK MANN.

103, Albert-street, Wednesbury, January 4, 1916.

EGYPTIAN COAL IMPORTS.—The quantity of coal imported into Alexandria in 1914 was 1,147,678 tons, as compared with 1,390,860 tons in 1913, and 1,311,092 tons in 1912. In these totals, imports from the United Kingdom figured for 1,024,500 tons in 1914, 1,222,082 tons in 1913, and 1,174,387 tons in 1912. The value of the coal imported into Alexandria in 1914 was 1,365,956*l*., as compared with 1,651,478*l*. in 1913, and 1,287,436*l*. in 1912. In these totals, the value of British supplies figured for 1,206,750*l*., 1,436,143*l*., and 1,136,368*l*. respectively.

PHOSPHORUS IN IRON AND STEEL.*

By W. H. HATFIELD, D.Met. (Sheffield).

THANKS to the pioneer work of Dr. J. E. Stead, F.R.S.,† supplemented by the researches of Dr. Saklatwalla, our knowledge of the binary alloys of iron and phosphorus is now based upon definite experimental work. The recent investigations of Dr. Stead‡ and Mr. Amioo§ have considerably extended the data available as regards the ternary and more complex alloys containing iron, phosphorus, carbon, and other elements, in which category steels must be placed. The complete elucidation of the influence of any element in the complex alloys found in ferrous metallurgy can only be accomplished by the continued contributions of various workers, and from this point of view it was thought that an account of some recent experiments made by the author upon the influence and condition of the phosphorus in high carbon alloys would be of interest to members of this Institute. It is, therefore, proposed to describe the experiments, and then to consider the results in connection with the previous work, with a view to seeing how and in what direction they supplement already-published data.

It is always of interest, and sometimes of considerable value, to be able to determine the condition and distribution of an element in an alloy, and when phosphorus in iron and steel is the subject of the inquiry, a particularly interesting and complex problem arises. At one end of the series are pig irons and cast irons with 3 to 4 per cent. of carbon, whilst at the other end it is necessary to study steels containing very small percentages of carbon. Both carbide and phosphide are soluble in iron, and when both compounds are present the phases of a ternary system have to be studied. Both Dr. Stead and Mr. Saklatwalla‖ have indicated that iron in the absence of carbon will retain about 1.70 per cent. of phosphorus in solid solution, and Dr. Stead has published the result of a valuable series of observations made upon the influence of the addition of carbon upon the amount of phosphide held in solution. His experiments indicated that by raising the carbon content of his alloy the phosphorus in solution was so reduced that with 3.50 per cent. of carbon only 0.31 per cent. of phosphorus was so held. His figures are here given :—

Phosphorus.

No.	Carbon.	Free as Fe_3P.	In Solution.	Total.
	per cent.	per cent.	per cent.	per cent.
1	Nil	Nil	1.75	1.75
2	0.125	0.18	1.37	1.55
3	0.18	0.59	1.18	1.77
4	0.70	1.00	0.75	1.75
5	0.80	1.06	0.70	1.76
6	1.40	1.16	0.60	1.76
7	2.00	1.18	0.55	1.73
8	3.50	1.40	0.31	1.71

By free phosphide is presumably meant phosphide which can be detected as a micro-constituent. It will be seen that commercial steels of fairly low carbon content form sufficiently "dilute" solutions of carbide to retain in solution quite a considerable percentage of phosphorus; whilst with 3.5 per cent. of carbon as much as 0.31 per cent. of phosphorus may be so retained.

Much of the discussion upon phosphorus in iron has of late dealt with the distribution of that element in the final steel or alloy, and after studying the influence of the varying percentages of the element upon high carbon alloys, it is proposed to continue the discussion of the distribution. The author has recently contributed* the results of experiments with the copper-depositing reagents devised by Dr. Stead and Dr. Rosenhain for the purpose of detecting irregular distribution of the phosphorus content, and in this paper he proposes to give some account of the use of such reagents in his experiments. For the purposes of the argument it is assumed that the carbon and phosphorus when in solution are in the forms of carbide and phosphide respectively.

THE AUTHOR'S EXPERIMENTS.

Alloys as Cast.—A series of high-carbon alloys (white irons) was prepared in which all the elements were in constant proportions with the exception of the phosphorus.

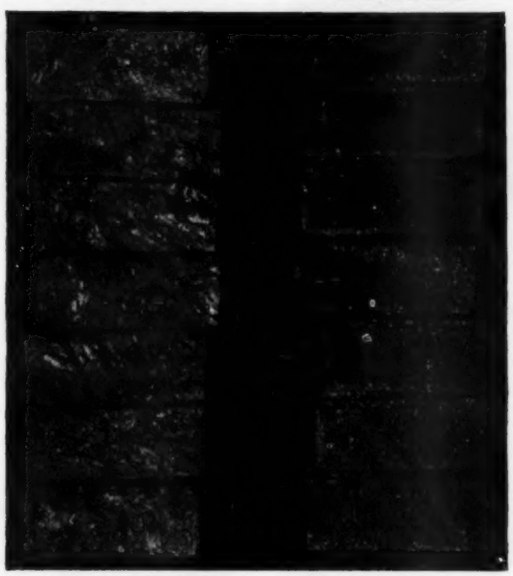


FIG. 1. FRACTURES OF TEST-BARS.

This element, as will be seen, increases in the series from 0.046 to 0.835. The analyses are here given :—

Bar.	Carbon.	Silicon	Sulphur.	Manganese.	Phosphorus.
	p.c.	p.c.	p.c.	p.c.	p.c.
P 1	2.90	0.75	0.038	0.25	0.046
P 2	2.80	0.77	0.038	0.25	0.10
P 3	2.90	0.76	0.041	0.252	0.145
P 4	2.89	0.78	0.041	0.26	0.229
P 5	2.87	0.77	0.038	0.25	0.287
P 6	2.84	0.77	0.039	0.28	0.60
P 7	2.83	0.76	0.036	0.25	0.83

The whole of the alloys presented fractures typical of white iron, as will be seen from the photographs reproduced in Fig. 1. The test-bars used were all of the standard section, 1 in. by ⅜ in., and were 8 in. long. Nothing at all peculiar was noticeable in the behaviour of these alloys during teeming.

As regards the hardness, it may be said that when tested upon the Brinell machine the bars all gave a hardness number in the immediate neighbourhood of 400.

The whole of the "as-cast" series were broken upon the tensile testing-machine with the following results :—

Bar.	Phosphorus Content.	Maximum Stress.
	per cent.	per sq. in.
P 1	0.046	16.39
P 2	0.10	14.44
P 3	0.145	17.60
P 4	0.229	16.51
P 5	0.287	11.21
P 6	0.60	14.72
P 7	0.83	13.37

From an examination of these figures it is obvious that all the bars consist of hard brittle iron, with very little to choose between the tenacity figures, and give little indication as to the influence of the phosphorus in the "as-cast" condition.

Micro-Examination of the Bars as Cast.—Sections from the whole of the series were examined after etching with picric acid, and all presented the well-known cementite-pearlite structure invariably associated with white cast iron. The structures are typified by Figs. 2, 3, and 4, page 20, which present respectively the structures of P 2, P 4, and P 7. It will be seen that the cementite membranes certainly appear a little thicker in P 7, Fig. 4, than in the other two, and the author believed this to be due to the phosphide occurring along with, and being indistinguishable from, the cementite carbide. Investigation, as will be shown, does not entirely confirm this view, and, indeed, the apparent difference is to be attributed mainly to the fact that the cementite was not so perfectly in focus in this micrograph as in the others. The actual visual examinations of the sections did, however, point to the membranes in P 7 being a little thicker than in the much lower phosphorus bars.

The sections after repolishing were heat-tinted, but the results obtained were not conclusive. After again grinding down and repolishing, the sections were subsequently treated with Dr. Stead's* copper-depositing reagent. The reagent was applied exactly as described by Dr. Stead. It was "dropped" on each section until the section would hold no more, and then allowed to stand for a minute or two. The sections were all treated alike and for the same period alongside each other. The result was of much interest; in the two minutes' treatment with the one dose they all had taken a copper deposit; P 1 was heavily coppered, whilst P 7 only obtained a distinctly noticeable film. The intermediate sections graduated in the heaviness of the deposit from that described for P 1 to that for P 7. When examined under the microscope, however, it was interesting to note that the pearlite in all the specimens had taken a distinct copper deposit, whilst throughout the series a slight film gradually developed upon the cementite-carbide in all the specimens. There was no definite indication of a distinction between free phosphide and free carbide in any of the samples, and this might be construed to point to much of the phosphorus being associated with the pearlite matrix. In the bars of low phosphorus content the pearlite was completely coated with copper, whilst as the phosphorus increased the pearlite came through the treatment more and more free from the deposit.

Heat-Treated Bars.—The bars were heat-treated in several ways, but the results given will be confined to those obtained from a treatment which consisted of heating up to a temperature of 900 deg. Cent. over a period of three days, maintaining that temperature for 2½ days and allowing to cool slowly. The tensile test results from these heat-treated bars are given in the following table :—

Bar.	Phosphorus.	Yield-Point.	Maximum Stress.	Elongation in 3 In.
	per cent.	tons per sq. in.	tons per sq. in.	per cent.
P 1	0.046	16.31	23.79	6.5
P 2	0.10	16.17	22.64	5.0
P 3	0.145	16.59	22.04	4.5
P 4	0.229	17.53	21.78	3.5
P 5	0.287	17.65	22.37	4.0
P 6	0.60	20.16	20.56	2.5
P 7	0.82	18.44	19.24	2.0

The distinctive feature is the curiously constant increase in the yield-point, which practically synchronised in a distinctly noticeable manner with the breaking stress during breaking in the bars P 6 and P 7. The elongation is steadily reduced in proportion. The breaking stress is fairly constant. It is obvious that the last two bars are extremely brittle. The fractures presented by these bars will be seen reproduced in Fig. 1, above. It will be seen that whilst P 1 to P 3 are black in fracture, a crystalline appearance begins to develop in No. 4, which entirely changes the type of fracture in the subsequent bars. It was found by various heat-treatments that P 1, P 2, P 3 and P 4 could all be rendered tough and ductile, but when the phosphorus exceeded 0.25 per cent., the physical properties of the bars became seriously impaired.

Micro-Examination.—Sections of heat-treated bar were prepared and etched with picric acid, and then examined with the following results :—

P 1. The structure consists of a matrix of ferrite through which some pearlite was dispersed; annealing carbon nodules appeared in the ferrite areas, no free phosphide was noticeable. See Fig. 5.
P 2. Ditto Rather less pearlite, no free phosphide.
P 3. Annealing carbon in ferrite, no free phosphide, only traces of pearlite, and the annealing carbon nodules were somewhat smaller.
P 4. Ditto Ditto
P 5. The annealing carbon appears in the ferrite only, traces of pearlite, and the phosphide begins to be discernible but only just.
P 6. Annealing carbon in ferrite with a definite appearance of free phosphide.
P 7. Annealing carbon in ferrite, with a considerable quantity of free phosphide.

In the latter bars of the series, where the precipitation of carbon is practically complete, here and there will be still found patches of pearlite. Fig. 6, page 20, represents such an area as found in P 7, and is instructive. The top right-hand portion of the micrograph represents the structure of the mass, the left-hand lower portion the pearlite patch. Free phosphide occurs indiscriminately in the ferrite and pearlite areas, but it is of in-

* Paper read before the Iron and Steel Institute.
† Journal of the Iron and Steel Institute, 1900, No. II.; ENGINEERING, October 19, November 2, 16 and 23, 1900.
‡ *Ibid.*, 1900, No. I.
§ *Ferrum*, August, 1914.
‖ Journal of the Iron and Steel Institute, 1908, No. II.

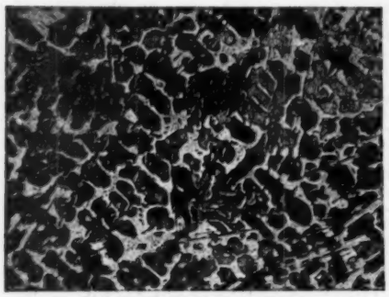
* Discussion on Dr. Stead's paper, Journal of the Iron and Steel Institute, 1915, No. I.

* Journal of the Iron and Steel Institute, 1915, No. I., page 173; ENGINEERING, June 4, 1915, page 640.

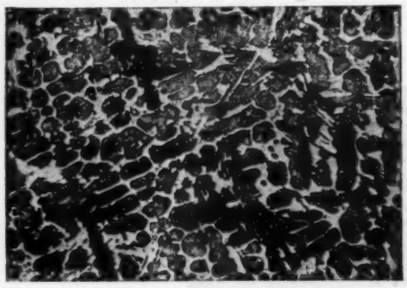
terest to note that the pearlite patch, when it does appear, seems to be in some way associated with the free phosphide. Fig. 7 represents such an area at high power. If some grey foundry cast irons be studied the same effect will be observed. Fig. 13, page 21, illustrates the structure obtained from such material, whilst Fig. 14 illustrates the same structure at high power. What is the meaning of this appearance of the pearlite and phosphide in juxtaposition?

Copper Deposition Examination.—Sections after repolishing were treated carefully by Dr. Stead's method with his reagent; again, as in the "as cast" state, an interesting result was obtained. The sections were all treated alongside in identical manner. P 1 after 1½ minutes was heavily coated with copper; P 7 at the other end of the series was still perfectly bright; P 6 had a faint copper tint; whilst P 2 and P 5 had a roughly progressively decreasing density of copper film. Subsequently dark boundaries (deposited copper) are fairly general and contained free phosphide, this free phosphide is also found in copper-free areas. It should be pointed out that the purity of a crystal of this type becomes less towards the exterior, and it is thus interesting to see that the pure centre should remain white whilst the copper is deposited on the less pure outer region. Leaving out of consideration for the present the suggested unequal distribution of the phosphorus, it might be remembered that Humfrey * has indicated a change in the molecular arrangement of the material at the regions of contact between crystals, and one might almost be inclined to find here a little indirect confirmation of his point of view. This aspect led to a very careful examination of the other samples, and in Figs. 15, 16, and 17 will be found the micrographs obtained from P 5. Fig. 15 typifies the structure obtained in the mass, and it compares with that shown for P 7 in Figs. 11 and 12. There is

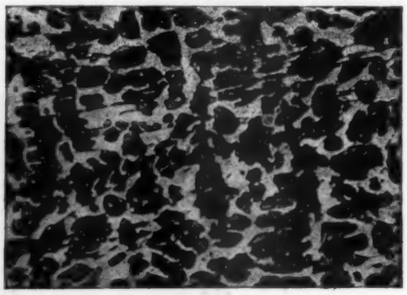
The Heat Treatment Discussed.—The heat treatment can profitably be studied. As cast, the material consisted of cementite-carbide and pearlite; upon reaching high temperatures, efforts are made by the material to attain equilibrium for those particular temperatures, and when those approximating to 900 deg. Cent. are reached, the cementite-carbide which has not gone into solution or already been dissociated will, upon further exposure to that temperature, be completely dissociated, the free iron produced going into the solid solution, the free carbon forming annealing carbon nodules. We thus have, finally, existing at the maximum temperature free carbon and solid solution of carbide in iron. As the material cools down carbide is progressively thrown out and decomposed, until when the Ar 1, 2, 3 point is reached we still have solid solution and free carbon as the two existent phases. During the recalescence the pearlite-carbide is thrown out, and either is or is not dissociated. If not, it continues



P 2.
FIG. 2.—Magnified 100 diameters and reduced one-third.

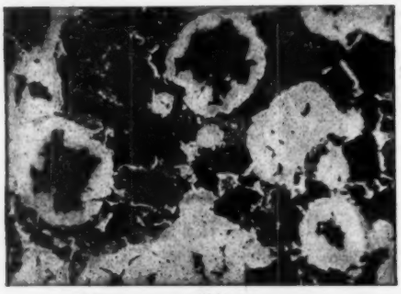


P 4.
FIG. 3.—Magnified 100 diameters and reduced one-third.

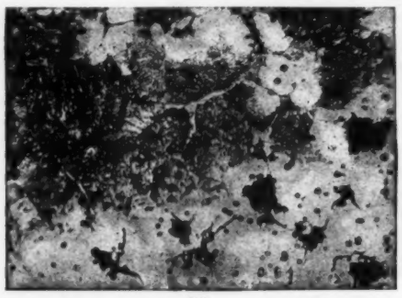


P 7.
FIG. 4.—Magnified 100 diameters and reduced one-third.

TEST-BARS AS CAST (HARD WHITE IRONS). ETCHED WITH PICRIC ACID.



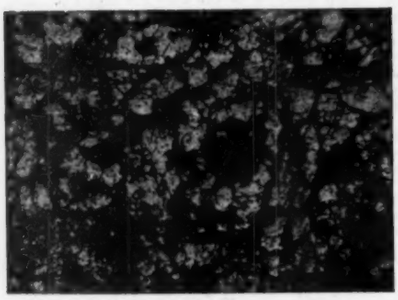
P 1.
FIG. 5.—Magnified 100 diameters and reduced one-third.



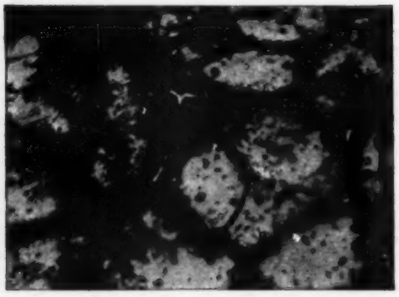
P 7.
FIG. 6.—Magnified 100 diameters and reduced one-third.

P 7.
FIG. 7.—Magnified 980 diameters and reduced one-third.

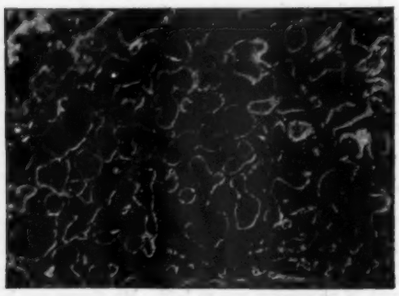
HEAT-TREATED IRONS ETCHED WITH PICRIC ACID.



P 5.
FIG. 8.—Magnified 100 diameters and reduced one-third.



P 5.
FIG. 9.—Magnified 980 diameters and reduced one-third.



P 5.
FIG. 10.—Magnified 100 diameters and reduced one-third.

HEAT-TREATED IRONS TREATED WITH DR. STEAD'S REAGENT.

the sections were examined microscopically after this treatment. Numbers P 1, P 4, and P 7 will be described in detail.

P 1.—Copper was well deposited over the entire section, the outer edge of the specimen having a very heavy deposit. The interior mass is illustrated in Fig. 15. It will be seen that the copper is deposited all over except about the annealing carbon nodules, around which, as shown in the micrographs, the metal remains white. This could not be due to local high phosphorus.

P 4.—A state was reached of copper deposition in which a structure was obtained, due to some of the ferrite being coppered and some not, which gave a fairly uniform structure of deposition, roughly corresponding to a pearlite structure in a 0.4 carbon steel.

P 7 is represented by the micrographs given in Figs. 11 and 12, but, as a matter of fact, the deposition is irregular, and sometimes the phosphide stands quite clear of the copper deposit. It will be seen that the deposition of copper has taken place in such a way as to suggest the demarcation of crystalline boundaries, and whilst such more deposition in the boundaries with lower phosphorus (obviously more, as seen in the micrographs). Fig. 9 illustrates the structure at high power. The most disturbing feature brought out of the examination of this section is illustrated in Fig. 10. If the micrograph is studied, it will be seen that the outer ring of material has taken its copper deposit in a curious manner. First of all it should be pointed out that, in using Dr. Stead's reagent in the manner he describes, the deposit is heaviest where the mass of the reagent tapers down to zero—that is, on the outer edge of the sample. If this micrograph be studied, it will be seen that the deposit in the boundaries appears to be become a broad band, and also that in the interior of the area a deposit is made, leaving the intermediate region white. The aspect of the matter is probably of little importance, as the outer regions do not represent the mass of the samples. It was, however, considered of sufficient interest to put on record.

* Faraday Society, 1914.

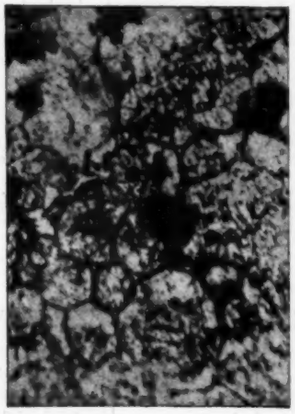
to exist as pearlite in the final material. The question is, What is happening to the phosphorus content in the different samples during this treatment? Unfortunately, the examination of the cast specimens gave a very indifferent clue as to how the phosphorus existed in that condition. Presumably it may be deduced that whilst some occurs with the cementite-carbide, much was present, as indicated by Dr. Stead's work, in the pearlite of the richer specimens. Did the phosphorus go into solution with the high temperatures? Figs. 6 and 7, above, are of interest from this standpoint, and it would appear quite safe to deduce that, with the higher percentages of phosphorus, a considerable proportion of the phosphide does not enter into solution, but that with the lower percentage it does. If that is so, why should pearlite be found, as shown, in juxtaposition with this free phosphide? Possibly it may be that the particular area is composed of the relatively undiffused decomposition products of the ternary eutectic, and hence is probably lower in silicon than the mass, and this would allow the pearlite-carbide produced in those areas to survive.

Still, it must be borne in mind that phosphide was found also occurring largely in ferrite. Another interesting feature that calls for notice is that generally there is less pearlite in the heat-treated specimens of the higher phosphorus content. This might partly be explained on the general ground that the carbon content becomes higher in the matrix owing to the quota of iron taken up to form the phosphide, thus facilitating the precipitation of the free carbon. Still it must be confessed that that is not a very convincing explanation of an interesting but an undoubted fact.

Comments on Copper-Depositing Reagents.—When judging the value of a reagent for determining local segregations of phosphorus, or, indeed, of any other element, it is essential to determine that the particular discriminating effect shall not be produced by other than the particular element under investigation, since, for instance, "rokes" have been determined as due to phosphorus when this could not reasonably be so. Interesting data have been recently produced by the use of cuprie reagents, and the author therefore gave this matter some attention, particularly after observing the structure represented in Fig. 15. In that particular microstructure it will be seen that white regions surround the annealing carbon nodules, and when it is considered that the phosphorus is well diffused owing to the longer anneal, and also present in low percentage, the white areas cannot be due to local high phosphorus. Fig. 16, above, indicates the result obtained when such "rokes" are examined transversely. It will be seen that the inclusions are surrounded by white areas, presumably high in phosphorus. As, however, the phosphorus contained in this particularly high-class steel was only 0.015 per cent., it would be unwise to attribute the appearance to local high phosphorus. It would seem to be that non-metallic inclusions of any kind are responsible for a prevention of a deposition in their immediate vicinity. A surface inequality such as a scratch or even a finger mark will affect the deposition. Great care, therefore, is required. Fig. 17 illustrates another area of the same section photographed in Fig. 16 and shows how scratches will prevent a local deposition of copper.

The Distribution of Phosphorus in Low-Carbon Material.—Dr. Stead's paper* on carbon, iron and phosphorus contained much data which should be very carefully studied. Some of his deductions were, however, of necessity, of a tentative kind, and only, unfortunately, capable of indirect proof. It is therefore probably of interest to discuss them from various points of view. The views expressed upon the distribution of phosphorus in mild steel are of particular interest, but several difficulties present themselves to the author's mind. Dr. Stead indicates that the primary "fir-tree" crystallites are lower in phosphorus than the surrounding material. That apparently must be so, and yet it must not be forgotten that the primary crystallisation bears only an indefinite relationship to the final structure resulting from the arrangement of constituents appearing with the breaking down of the solid solution. Primary crystals commence to separate on the liquidus curve, and progressively grow to the solidus, and the actual variation in concentration is dependent upon the exact position of those lines, which, unfortunately, cannot as yet be accepted as finally marked out. We have, therefore, immediately upon solidification a heterogeneous solid solution which, at any rate in low-carbon steels, will become more or less homogeneous during the cooling when passing through the region extending from the solidus to the Ar 3 point. At this temperature (the Ar 3 point) iron begins to precipitate from the solid solution, and the ferrite thus appearing should logically contain less phosphorus than the remaining solid solution. In the first place, it must be clear that the, after all, very small quantity of phosphide in the steel is most probably in solution along with the carbide when in the γ range. If so, does not the phosphide remain largely in the areas which become pearlite? The further question is, If so, does it remain in solid solution after the pearlite carbide is precipitated, or is it thrown out as phosphide amongst the pearlite carbide? Iron has a greater solvent power for carbide than for phosphide, and it might reasonably be expected that, since carbide is insoluble in iron in the α range, the phosphide would also be thrown out. It may, of course, remain in solid solution in the iron, or may even be in colloidal suspension.

Dr. Stead suggests that in steels where the phosphide is not uniformly diffused the ferrite first precipitates in the regions rich in phosphorus. Now, considering an average mild steel such as he mentions, would not the reverse be the case, as those portions richest in carbon are also richest in phosphorus (compare Talbot,* and Hadfield and Burgess†)? It would appear to the author that the iron in those areas would be held (compare iron-carbide equilibrium diagram) down to the lower temperatures, and the portions lowest in concentration of carbide and phosphide would precipitate iron first. As a study in segregation conclusively indicates that the parts rich in phosphorus are high in carbon, the separation of ferrite must in these areas take place at a lower temperature, and hence it may be deduced that the primary ferrite contains, either in solution or associated with it in one way or another, the least proportion of the phosphorus. Hence the thick ferrite envelopes* in steel castings are not as high in phosphorus as is suggested, and, if that be so, Dr. Stead's suggestion that the critical range is exceeded, to the unconscious purpose that they may diffuse, will probably have to be reconsidered. No doubt the necessity for this higher temperature is due to the advisability of producing more complete homogeneity than that which is sometimes attained between the primary and secondary crystals during freezing and subsequent cooling. If a steel casting be examined, it will be found that there is frequently an obviously unequal distribution of the pearlite, probably caused through the solid solution, representing the last portions to freeze, producing areas of higher carbon content, and, it might be also deduced, higher phosphorus content. The whole of Dr. Stead's micrographs, particularly 22 and 23, already indicate that the primary crystals, lower in both phosphorus and carbon, take the copper, those portions apparently last to freeze refusing a deposit. Obviously, then, in a mass of steel, the drawn-out, segregated portions will be left more or less alone by the copper deposit. It will be, however, clear that a distinction must be made between inequalities such as "ghosts," produced by normal segregation, and those resulting from other causes.



P 7.

FIG. 11.—Treated with Dr. Stead's reagent. Magnified 100 diameters and reduced one-third.

P 7.

FIG. 12.—Treated with Dr. Stead's reagent. Magnified 980 diameters and reduced one-third.

FIG. 13.—Grey foundry cast iron. Magnified 80 diameters and reduced one-third. Etched with picric acid.

FIG. 14.—Grey foundry cast iron. Magnified 1000 diameters and reduced one-third. Etched with picric acid.

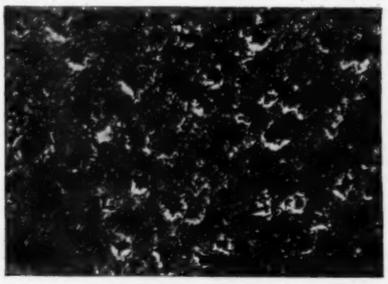


FIG. 15.—P 1, heat-treated. Treated with Dr. Stead's reagent. Magnified 60 diameters and reduced one-third.

FIG. 16.—Steel. Treated with Dr. Stead's reagent. Magnified 60 diameters and reduced one-third.

FIG. 17.—Steel (scratched). Treated with Dr. Stead's reagent. Magnified 60 diameters and reduced one-third.

FIGS. 15 TO 17. CARBON, 0.65 PER CENT.; SILICON, 0.23 PER CENT.; MANGANESE, 0.30 PER CENT.; SULPHUR, 0.024 PER CENT.; PHOSPHORUS, 0.015 PER CENT.

THE EMIGRATION OF SKILLED SWEDISH LABOUR.—Considerable concern is felt in several Swedish industries, more especially the metal branch, at the increasing number of skilled Swedish hands who are being engaged by foreign agents to work in other countries. Swedish employers state they cannot offer such high wages, and must also abide by the agreements, and so far no means have been found to prevent the men going to countries where they get better pay.

THE ROYAL SANITARY INSTITUTE.—The Institute announces the following:—The sixty-first course of lectures and demonstrations for sanitary officers will commence on Monday, February 7; a course of lectures on school hygiene, including elementary physiology, and for women health visitors, school nurses, and tuberculosis visitors, will commence on Monday, February 21; a course of practical training for meat inspectors will commence on Friday, February 18. Sessional meeting, London, early in March. Discussion on "Standard of Purity of Food Supplies in War Time," by Mr. J. Wright Mason, Hull.

* Journal of the Iron and Steel Institute, 1915, No. 1; ENGINEERING, May 21 and 28 and June 4, 1915.

* Journal of the Iron and Steel Institute, 1905, No. II.
† *Ibid.*, 1915, No. I.; ENGINEERING, May 14, 1915.

* Stead, Journal of the Iron and Steel Institute, 1915, No. I., page 150; ENGINEERING, June 4, 1915, page 639.

ELECTRICAL RAILWAYS.*

By HENRY METCALF HOBART, M. Inst. C.E.

RETROSPECTIVE.

DURING the last twenty-five years electricity has been employed to a rapidly-increasing extent as a motive power for trains. At the beginning of this period the art of manufacturing electricity was in its incipient stages, the supply was limited and the cost was high. The growth of the electricity-supply business has been very rapid, and thousands of miles of railways are so situated as to be able to purchase at a very low price all the electricity they would require were they to undertake to adopt electric propulsion for their entire traffic.

Although trains hauled by electric locomotives were in regular operation in 1890 on the City and South London Railway, the first application of electricity to train haulage in America was in May, 1895, when electric locomotives were employed by the Baltimore and Ohio Railroad to haul trains through its Belt Line Tunnels in Baltimore. The rate at which the electrification of sections of American steam railways has grown since that date may be seen from the following table:—

Year.	A.—Electrically-Equipped Single-Track Mileage of Steam Railways in the United States and Canada.	B.—Total Single-Track Mileage of Steam Railways in the United States and Canada.	$\frac{100\,A}{B}$
	miles	miles	
1895	8	233,000	..
1900	51	259,000	..
1905	215	307,000	..
1910	1580	352,000	0.45
1915*	3460	380,000	0.91

* The figures for 1915 include mileage now being electrified.

The above figures, however, do not indicate the growth of the electric railway industry in America. The greatest activity has heretofore related chiefly to independent electric railway undertakings not necessarily involving the operation of trains. The rapid growth of this business is indicated by the statistics in the following table:—

Year.	Total Single-Track Mileage of Electric Railways in the United States and Canada.	Total Number of Motor-Cars.
	miles	
1890	1,260	5,600
1895	12,100	26,000
1900	19,300	43,600
1905	32,500	64,000
1910	40,000	89,600
1915	45,000	100,000

Thus we see that in 1915, while the electric railways in the United States and Canada comprise an aggregate of 45,000 miles of single track, the electrically-equipped single-track mileage of steam railways is only 3460 miles, and still constitutes less than 1 per cent. of the total single-track mileage of steam railways.

RAPID DECREASE IN COST OF ELECTRICITY.

The accelerated growth of the electric railway industry has been in no small measure a consequence of, and has always been a contributory cause of, the continual decrease in the cost of manufacturing electricity. It would have been impossible twenty years ago to manufacture electricity at a cost of much less than 3d. per kilowatt-hour. Ten years ago a price of 1d. per kilowatt-hour would usually have been the minimum permitting of any profit. At present there are electricity-supply undertakings which could make a profit in supplying electricity to railways in their district at but little over ¼d. per kilowatt-hour. Indeed, many millions of kilowatt-hours have during the last couple of years been delivered on the premises of the Butte, Anaconda and Pacific Railway at a price of 0.265d. per kilowatt-hour, and employed by the railway in the movement of millions of tons of ore and other freight. In the electric operation of 440 miles of its main line over the Rocky Mountains, the Chicago, Milwaukee and St. Paul Railway will pay 0.260d. per kilowatt-hour for electricity delivered to its high-pressure tie-in line. In both these cases the electricity is generated from water-power, and the conditions are exceptionally favourable.

Fifteen years ago the best available electricity-generating sets consisted of slow-speed reciprocating engines direct-connected to electric generators. A 3000-kilowatt set was considered to be about as large as could be used to advantage. Such an engine and generator cost some 30,000*l.* or (10*l.* per kilowatt). At present 30,000-kilowatt steam-turbine-driven sets are available at a price considerably below 60,000*l.*—that is to say, the set with ten times the output costs less than twice as much.

Furthermore, while the 3000-kilowatt generating set of fifteen years ago consumed some 18 lb. of steam per kilowatt-hour, the present-day 30,000-kilowatt set only consumes some 12 lb. of steam per kilowatt-hour, *i.e.*, two-thirds as much. The corresponding progress in steam-raising plant and condensing plant has also been by no means inconsiderable, and in conjunction with the requirement of only two-thirds as much steam and fuel, may be roughly taken as at least halving the initial outlay per rated kilowatt installed for these components of an electricity-manufacturing plant.*

RELATIVE MERITS OF HYDRO-ELECTRIC AND STEAM STATIONS.

Developments in hydro-electric installations for manufacturing electricity have been also very satisfactory, but in districts where coal is obtainable at a low price it is rarely possible for a hydro-electric plant to supply electricity at a competitive price except for applications with a fairly high load-factor. The influence of the load-factor on the relative appropriateness of steam and hydro-electric means of manufacturing electricity is very appreciable, and it is important that it should be understood. For a hydro-electric undertaking which is not dependent (or but slightly dependent) upon storage water or steam reserve, the annual cost of supplying any consumer is closely proportional to the kilowatts of his maximum demand, and is nearly independent of the quantity of electricity which he consumes per annum. For example, if a railway's maximum demand from a typical hydro-electric station is 30,000 kilowatts, it costs almost as much to supply the demand irrespective of whether the 30,000 kilowatts is required for twenty-four hours a day during the entire 365 days in the year, which would amount to 262 million kilowatt-hours per annum, or whether it is only required for, say, one-tenth of the time. In the latter case the cost per kilowatt-hour would be nearly ten times as great as in the former case. But in a coal-burning generating-station the annual outlay for fuel is fairly proportional to the total number of kilowatt-hours consumed per annum, and with coal at anything more than an exceedingly low price, the outlay for the coal will be quite a substantial percentage of the total cost of manufacturing the electricity. The very low initial cost per kilowatt, of large modern electricity-supply stations employing steam-turbines, contributes largely to bringing this about. The price for electricity manufactured in a coal-burning station is consequently much less controlled by the maximum demand, and much more controlled by the quantity of electricity consumed in a given time, than in the case of a hydro-electric undertaking. While all outlays for water-storage or steam reserves for a hydro-electric undertaking tend to increase the influence of the total kilowatt-hour consumption on the cost, there can be very liberal provisions of this kind without materially impairing the correctness of the proposition that a high-load factor will permit of effecting a greater reduction in the cost of manufacturing electricity (as compared with the cost of the same quantity of electricity but of low load-factor) in the case of a hydro-electric station than in the case of a coal-burning generating-station.

On various occasions engineers have drawn attention to this distinctive difference between hydro-electric and steam-electric generating-stations. The arrangement of the curves in Figs. 1 and 2 was suggested by data given

Fig. 1.

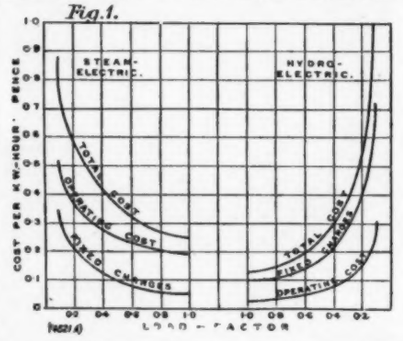


FIG. 1. INTERDEPENDENCE OF COST OF ELECTRICITY AND LOAD FACTOR FOR STEAM AND HYDRAULIC STATIONS.

by Mr. Henry Flood, Jun., in a paper entitled "Hydro-Electric Development."† The curves are based on appropriate assumptions as to the first cost of a hydro-electric station and a transmission-line to the desired district in the one case, and of a steam station located in that district (and hence not requiring a transmission-line) in the other case. It will be seen that while the fixed charges are much lower than the operating costs for the steam undertaking, the reverse is the case for the hydro-electric undertaking. This is in accordance with the well-known attributes of such undertakings, and requires no comment. The two curves of the total cost of electricity in Fig. 1 are brought together in Fig. 2, from which it is seen that while, for very low load-factors, the steam undertaking can supply electricity at the lowest cost, when we come to load-factors above 0.20 the hydro-electric undertaking has the advantage, and that for unity load-factor the hydro-electric undertaking can supply electricity at practically half the price attainable with the steam undertaking. While every case requires a separate analysis, it may be said that the curves in Figs. 1 and 2 are thoroughly typical. Since an extensive electrically-

Fig. 2.

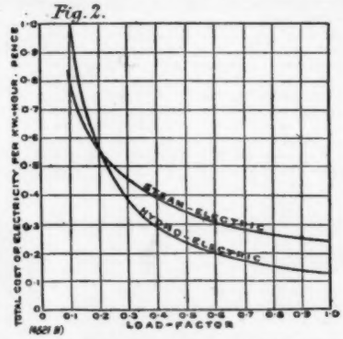


FIG. 2. COMPARATIVE COST OF ELECTRICITY FOR STEAM-ELECTRIC AND HYDRO-ELECTRIC STATIONS.

operated railway will have a fairly good load-factor, the curves indicate one reason for the remarkable progress which has already been made with railway electrification in countries which are rich in water-power.

INFLUENCE OF THE FUEL COST ON THE COST OF MANUFACTURING ELECTRICITY IN STEAM-ELECTRIC GENERATING-STATION.

The total cost of manufacturing electricity may conveniently be considered as made up as follows*:—

Total cost of electricity at outgoing cables from generating-station.
- Production costs.
  - Fuel.
  - Oil and Stores.
  - Wages and Salaries.
  - Repairs.
- Investment costs.
  - Interest.
  - Rates and Taxes.
  - Insurance.
  - Amortisation.
- Administration costs.

It is desired to set forth the effect exerted on the total cost by variations in the fuel cost, all the other component costs remaining unchanged. Consequently, for the above scheme of segregation of costs we shall substitute the following:—

Total cost of electricity at outgoing cables from generating-station.
- Fuel component of production costs.
- Remaining components of production costs, plus investment costs, plus Administration costs.

This has been worked out for a 150,000-kilowatt generating-station equipped with five 11,000-volt, 50-cycle, 1500 revolutions per minute, three-phase, steam-turbine-driven generating sets, each with a continuous rating of 30,000 kilowatts at unity power-factor. The station has a favourable location as regards an ample supply of circulating water, and as regards low cost for land and buildings. The fuel has a calorific value of 14000 B.Th.U. per lb. The load-factor at the generating-station is 0.50.

For such conditions representative figures for the costs per kilowatt-hour of output from a modern generating-station for various fuel costs are shown in the following table:—

Cost of Fuel per Ton.	Fuel Cost per Kilowatt-Hour.	All Remaining Costs per Kilowatt-Hour.	Total Cost per Kilowatt-Hour of Electricity as Delivered from the Generating-Station.
s.	d.	d.	d.
4	0.038	0.190	0.228
6	0.056	0.190	0.246
8	0.075	0.190	0.165
10	0.094	0.190	0.284
12	0.112	0.190	0.302

It is interesting to note that increasing the price of fuel three-fold, namely, from 4s. per ton to 12s. per ton, increases the cost of the electricity, under these conditions, by 33 per cent., since $\frac{0.302}{0.228} = 1.33$. The percentage influence of the cost of fuel will obviously be less the greater the aggregate of the remaining cost. For a generating-station located in or near a large city, the greater cost for land and buildings alone might occasion a 100 per cent. increase in the sum of all costs other than fuel, so that while with fuel at 4s. per ton the electricity would cost

$$0.038 + 0.380 = 0.418\text{d. per kilowatt-hour,}$$

the cost with fuel at 12s. per ton would be

$$0.112 + 0.380 = 0.492\text{d. per kilowatt-hour,}$$

or an increase of only 18 per cent. in the cost of electricity

* James Forrest Lecture, delivered before the Institution of Civil Engineers, on Tuesday, December 14, 1915. In the enforced absence of Mr. Hobart in America, this lecture was delivered on his behalf by Mr. John A. F. Aspinall, M. Inst. C.E.

* In this connection reference should be made to a paper by Messrs. Stott, Pigott and Gorsuch, entitled "Present Status of Prime Movers," and published at page 953 of the Proceedings of the American Institute of Electrical Engineers for June, 1914.

† This paper was read at Schenectady on May 7, 1915, on the occasion of a joint meeting of the Eastern New York Section of the National Electric Light Association and the Empire State Gas and Electric Association. Mr. F. G. Baum also elaborates the distinction in the course of a paper entitled "Class Rates for Electric Light and Power Systems or Territories," published at page 485 of the Proceedings of the American Institute of Electrical Engineers for April, 1915.

* See paper entitled "Standardisation of Method for Determining and Comparing Power Costs," by H. G. Stott and W. S. Gorsuch, at page 1619 of vol. xxxii of the Transactions of the American Institute of Electrical Engineers.

with a three-fold increase in the price of fuel. For 8s. per ton the cost would be

$$0.075 + 0.380 = 0.455\text{d. per kilowatt-hour.}$$

The limitations of the present paper will only permit of touching briefly on the additional costs associated with the transmission of electricity over considerable distances, although this is a very important factor in the application of electricity to the working of main-line railways.

If the output of the 150,000-kw. generating-station above considered is transmitted by overhead conductors to an average distance of 100 miles, the additional investment costs associated with the step-up and step-down transformers and the transmission-line, together with the operating costs for these links in the system, will add about 0.18d. to the cost per kilowatt-hour, delivered at the 100-miles-distant low-pressure terminals of the step-down transformers, if the load is transmitted over ten different routes, and consequently divided amongst ten separate transmission-lines from the generating-station, each transmission-line comprising six conductors carried on steel towers. But if the entire quantity of electricity were to be transmitted 100 miles *en bloc* over six conductors carried by a single line of steel towers, the increase in cost would only be of the order of 0.08d. per kilowatt-hour.

Reverting to the costs of electricity at the generating-station with fuel at 8s. per ton, which have already been set forth as ranging from 0.265d. to 0.455d. per kw.-hour, and adding these transmission costs we have:—

Cost per Kilowatt-Hour of 0.5 Load-Factor, Unity-Power-Factor Electricity at the 150,000-Kw. Generating-Station with Fuel at 8s. per Ton.	Cost per Kilowatt-Hour Delivered from the Low-Pressure Terminals of the 100-Miles-Distant Step-Down Transformers.	
	Transmission *en bloc*.	Transmission over Ten Independent Lines of Towers.
d.	d.	d.
0.265	0.345	0.445
0.455	0.535	0.635

It should be evident that in other than an involved analysis, which would be quite beyond the scope of the present paper, it would be out of the question to give more than the above broad indications of the order of magnitude of the costs under the various conditions which occur in dealing with railway-electrification undertakings.

Higher load-factors reduce the investment costs and consequently also the total cost. The transmission of smaller quantities of electricity is associated with higher costs. Loads with a lagging power-factor, unless compensated by loads with a leading power-factor, can only be supplied at an increased cost. Every additional transformation of pressure, periodicity, or kind, of electricity increases the cost.

Load-Factor and Diversity Factor with Electric Locomotives

To obtain a high load-factor with electrically-propelled trains, it becomes necessary either to have a dense service or else to extend over a large mileage of track. By either expedient, the object is accomplished of averaging the widely-varying individual consumptions of many electric locomotives. Even if the average consumption of an individual electric locomotive may, during several hours in service, only amount to, say, 15 per cent. of its maximum consumption during those hours—that is to say, even if its individual load-factor is only 0.15, the combined average consumption of, say, thirty such locomotives, will have a load-factor more of the order of, say, 0.60. If the thirty locomotives are all supplied with electricity from one source, the cost of electricity will be that corresponding to the combined load-factor, which in the above example has been assumed to be 0.60. The ratio of the combined load-factor of the thirty locomotives to the average of their individual load-factors is termed the "diversity factor." In our example, the diversity factor is $\left(\frac{0.60}{0.15} = \right) 4.0$.*

Representing by 15 the average consumption of the single locomotive, then its maximum consumption is 100. The average consumption of the thirty locomotives is $(30 \times 15 =) 450$, and their maximum consumption is $\left(\frac{450}{0.6} = \right) 750$, or only 7.5 times the maximum consumption of a single locomotive. The sum of the maximum consumptions of the thirty locomotives is $(30 \times 100 =) 3000$. The diversity factor of the system is $\left(\frac{3000}{750} = \right) 4.0$.

One of the most important attributes of the electric-locomotive system of propelling trains relates to the ability to take scientific advantage of the diversity factor of a system comprising many locomotives in providing a high resultant load-factor and to secure economies incident thereto. In fact, the resultant load-factor of the railway's load will combine with the resultant load-factor of the loads of other consumers to yield an ultimate resultant load-factor at the generating-station which will usually be appreciably better than the railway's own load-factor. Consequently, a railway rarely manufactures its own electricity, for its own exclusively-railway load, at so low a cost as that at which it can be manufactured by an electricity-supply company whose system comprises the loads of other large consumers.

Electric-Locomotive Operation of Mountain-Grade Railways.

It is only recently that the electrical industry has grown to the stage which permits of putting these principles into practice on so large a scale as conclusively to demonstrate their correctness. The first extensive application of electric propulsion to a mountain-grade system employing a considerable number of freight locomotives is that of the Butte, Anaconda and Pacific Railway, which will now be described.

The Butte, Anaconda and Pacific 2400-Volt Railway.*

Prior to the summer of 1913 the trains on the Butte, Anaconda, and Pacific Railway were hauled exclusively by steam locomotives. The railway comprises 114 miles of single track, of which some 70 miles is in yards and sidings. There is very little tangent track in the course of the entire 114 miles. For the twelve months preceding June, 1913, the traffic aggregated about 760,000 locomotive-miles. This traffic was handled with twenty-seven steam locomotives, giving an average of 28,000 miles per steam locomotive per year. The steam-locomotives were of the following types:—

Number	Type.	Average Weight with Loaded Tender.	Weight on Drivers.
		British tons*	British tons.
15	Consolidation and miscellaneous	138	74
10	Mastodon	145	74
2	Passenger	118	54
27	= total number of steam-locomotives.		

* Throughout this paper the ton of 2240 lb. has been used, and in most instances this has been expressly termed the "British ton" to avoid any confusion with the 2000-lb. ton usually employed in America.

The 760,000 locomotive-miles per annum were distributed as follows:—

Service.	Locomotive-Miles per Annum.	Percentage of Total Annual Locomotive-Miles.
Switching	310,000	41
Freight	300,000	39
Passenger	84,000	11
Non-revenue and special ..	66,000	9
Total	760,000	100

The annual coal consumption for these twenty-seven locomotives amounted to 67,000 British tons. This reduces to 197 lb. of coal per locomotive-mile. The price of the coal, delivered at the bins of the railway company, was 19s. per British ton. This works out at a fuel cost of 19.9d. per locomotive-mile. The fuel is lignite, and has a calorific value of 12,250 B.Th.U. per lb. (3.60 kw.-hours per lb.).†

Ninety-one miles of single track of this system have now been equipped for electric operation, and all but four of the twenty-seven steam locomotives have been withdrawn from service. The remaining 23 miles of single track will soon be ready for electric operation, and the four steam locomotives will then be withdrawn. They are at present employed chiefly on various duties on a system of non-electrified tracks and sidings at the copper-mines on Butte Hill.

At present the annual traffic is slightly greater than during the last year of "all-steam-locomotive" operation. This traffic is handled with seventeen electric locomotives and the four steam locomotives above mentioned. These four steam locomotives now account for 130,000 locomotive-miles per annum, or an average of 32,500 miles for each locomotive. They are burning 11,300 British tons of coal per annum, or 193 lb. per locomotive-mile. This, at 19s. per ton, amounts to 19.5d. per locomotive-mile, substantially the same figure per locomotive-mile as during the time of "all-steam-locomotive" operation.

The seventeen electric locomotives are at present accounting for 700,000 locomotive-miles per annum. This is an average of 41,000 miles per electric locomotive per annum. The energy consumed by the seventeen electric locomotives requires the supply to the sub-stations of 18,500,000 kilowatt-hours of electricity per annum, or 26.3 kilowatt-hours per locomotive-mile. The electricity is delivered to the sub-stations at a price of 0.265d. per kilowatt-hour. Consequently the expenditure for electricity per locomotive-mile amounts to $(26.3 \times 0.265 =) 7$d.

Tabulating these results we have:—

	Outlay for Fuel and Power per Locomotive-Mile.
	d.
Prior to the summer of 1913, when employing twenty-seven steam locomotives	19.9
At present, with four steam locomotives and twenty-seven electric locomotives { Per steam locomotive-mile	19.5
At present, with four steam locomotives and twenty-seven electric locomotives { Per electric locomotive-mile	7.0

Thus the outlay for electricity per locomotive-mile is only 7d., as against an outlay of 19.9d. for coal per steam locomotive-mile. Too much significance, however, should not be attached to this ratio, since it is largely dependent upon local conditions. For the same price (0.265d. per kw.-hr.) for electricity, but with coal of the same quality—at, say, 8s. per ton—the outlay for fuel per locomotive-mile would only have been $(8/19 \times 19.5 =)$ 8.2d. per steam locomotive-mile. Furthermore, notwithstanding the gradual decrease in the cost of manufacturing electricity, conditions will usually make it quite out of the question to obtain electricity at so low a price as 0.265d. per kilowatt-hour. Had it been necessary to pay a 50 per cent. higher price for the electricity—namely, 0.40d. per kilowatt-hour—the outlay for electricity per locomotive-mile would have been 10.5d., which would correspond to an outlay for fuel per steam locomotive-mile on the basis of coal at $\left(\frac{10.5}{19.5} \times 19 = \right) 10.2$s. per ton.

Each of the seventeen electric locomotives weighs 72 British tons, and the entire weight is on the drivers. The weight per axle is 18 tons. Fifteen are employed in freight service and two in passenger service. A type of motor known as the G.E. 229 A is employed both on the freight and passenger locomotives, the only difference relating to the gear ratio, which for the freight locomotives is $(87 : 18 =) 4.83$, and for the passenger locomotives is $(80 : 25 =) 3.20$, the passenger locomotives thus having a 51 per cent. higher speed for a given speed of the armature. The locomotives receive 2400-volt direct-current* (D.C.) electricity from overhead conductors by means of roller pantograph trollies. Each of the four motors constituting the equipment of a locomotive is wound for a working pressure of 1200 volts, and the winding is insulated for a pressure to ground of 2400 volts. The motors are permanently connected in pairs of two in series. By series-parallel control the two pairs can be operated in series or in parallel with one another. The maximum free-running speed of the freight locomotives is about 35 miles per hour. Each freight locomotive is capable of developing continuously a tractive effort of 25,000 lb. at 16.2 miles per hour, the corresponding output at the drivers being—

$$\frac{25{,}000 \times 16.2 \times 5280}{60 \times 33{,}000} = 1080 \text{ H.P.}$$

At starting, the locomotive provides a tractive effort of 40,000 lb. for a coefficient of adhesion of 0.25, and 48,000 lb. for a coefficient of adhesion of 0.30. The thermal characteristics are such as to permit of the development of a tractive effort of 48,000 lb. for five minutes, starting cold. This five-minute rating provides a valuable margin for the slow acceleration from rest of long freight trains on heavy grades; in other words, it provides liberal emergency capacity. Another occasion when this five-minute rating is utilised is when a very long freight train is headed by one locomotive and pushed by another. The inability to maintain prompt communication between the ends of a long train may occasion the pusher to consume electricity for some time in the vain attempt to start the train without the co-operation of the locomotive at the head of the train. A properly-designed freight locomotive serving as pusher under these conditions can, for some five minutes, absorb without any injury enough electricity to slip the driving-wheels. The electrical equipment of the locomotive weighs 60,000 lb., or 55.5 lbs. per horse-power of continuous output at the rims of the

* The following are approved definitions of the term "load-factor" and "diversity factor":—

"The load-factor of a machine, plant, or system. The ratio of the average power to the maximum power during a certain period of time. The average power is taken over a certain period of time, such as a day, a month, or a year, and the maximum is taken as the average over a short interval of the maximum load within that period.

"In each case the interval of maximum load and the period over which the average is taken should be definitely specified, such as a 'half-hour monthly' load-factor. The proper interval and period are usually dependent upon local conditions and upon the purpose for which the load-factor is to be used." (Standardisation Rules of the American Institute of Electrical Engineers, Edition of July 1, 1915, page 12.)

"The 'diversity factor' is the ratio of the sum of the maximum power demands of the subdivisions of any system, or parts of a system, to the maximum demand of the whole system, or of the part of the system, under consideration, measured at the point of supply." (Standardisation Rules of the American Institute of Electrical Engineers. Edition of July 1, 1915, page 13.)

* The author wishes to acknowledge the cordial assistance which has been given to him by Mr. J. B. Cox in those sections of the paper which relate to the electrification of the Butte, Anaconda and Pacific Railway. Mr. Cox was responsible for the installation of the electric locomotives on this railway, and is the author of two papers in which the railway is described. These papers are:—"The Electrical Operation of the Butte, Anaconda and Pacific Railway," Proceedings of the American Institute of Electrical Engineers, 1914, page 1729, and "Contact System of the Butte, Anaconda and Pacific Railway," Proceedings of the American Institute of Electrical Engineers, 1915, page 1447.

† One kilowatt-hour = 3411 B.Th.U. Consequently, for coal of this quality, the calorific value of a British ton is $\left(\frac{2240 \times 12{,}250}{3411} = \right) 8100$ kilowatt-hours.

* The term "direct current" (or D.C.) is used throughout the paper instead of "continuous current" in order to avoid confusion with the use of the word "continuous" as a kind of rating. The British Engineering Standards Committee and the American Institute of Electrical Engineers both subdivide ratings into two sorts; the one sort is termed the "Continuous Rating," and the other sort is termed the "Short-Time Rating." This use of the word "continuous" has recently become of such frequent occurrence in electrical engineering publications as to render it desirable to avoid its use for designating a "kind" of electrical current.

drivers. Conversely expressed, the locomotive is capable of delivering continuously at the drivers an output of 40.5 horse-power per British ton of weight of electrical equipment. The motors are cooled by the circulation through them of air supplied from a motor-driven blower.

The traffic of the Butte, Anaconda and Pacific Railway has up to the present consisted chiefly in the transportation of some 5,000,000 tons of ore annually from the copper mines on Butte Hill to the Washoe smelter on Smelter Hill, a distance of about 31.5 miles by rail. This section has grades up to 2.5 per cent. at some portions. Owing to the success of the electrical service, it was, in 1914, decided to treat at the Washoe smelter a further 1,000,000 tons or ore per year, which had previously been treated at the Great Falls smelter. The total quantity of ore transported annually will consequently henceforth be more of the order of at least 6,000,000 tons. To provide for this increase, additional sub-station machinery has been installed, and also four more electric freight locomotives.

Four tractor trucks have also been added to the rolling-stock equipment. Each tractor truck is equipped with two motors, and can be used with any one of the nineteen freight locomotives which are equipped with the necessary switch and cable connections. A locomotive with its tractor truck carries six motors, and the combination has a weight of 108 British tons. The control is so arranged that the six motors can be operated either all in series or in two parallels of three in series. A locomotive with one of these tractors is thus capable of exerting continuously a tractive effort of 37,500 lb. at 10.8 miles per hour.

For a road of the character of the Butte, Anaconda and Pacific Railway it is difficult to arrive at a satisfactory basis on which to establish comparisons. The locomotive-mile is an unsatisfactory common denominator, since widely-different abilities pertain to different types of electric locomotives. The difficulty is accentuated by the large percentage which the "switching" mileage and the "non-revenue and special" mileage bear to the total annual mileage of the locomotives. These percentages are as follow :—

Kind of Locomotive-Mileage.	Percentage of Total Annual Locomotive-Mileage.	
	With Twenty-Seven Steam Locomotives.	With Four Steam and Seventeen Electric Locomotives.
	per cent.	per cent.
Switching	40.5	32.9
Non-revenue and special ..	9.3	4.3
"Switching" plus "Non-revenue and special"	49.8	37.2

The data in the above table afford evidence of the superiority of the electric locomotive for switching work and of the relatively small amount of non-revenue mileage associated with its use.

The net ton-mileage of freight carried annually by the railway is at present some 170 million ton-miles. No data are available to show the total ton-mileage, but, exclusive of the locomotives, it is probably about 340 millions. Exclusive of the passenger service, the locomotive-mileage is about 775,000 per annum, making a further (7 × 775,000 =) 56 million ton-miles, or a total, including locomotives, of some 400 million ton-miles per annum.

Increased Weight of Trains Hauled by Electric Locomotives.—Whereas in the days of "all-steam-locomotive" operation the average weight of the ore-trains for the main-line portion of the journey from the mines to the smelter—*i.e.*, for the 20-mile run from Rocker to East Anaconda, shown in Fig. 3—was about 1600 British tons, the average weight with electric traction has been increased 35 per cent. to about 2100 British tons. Trains composed of sixty-five loaded ore-cars, with an average weight of about 63 British tons per car, headed by two 72-ton electric locomotives, and weighing (complete with locomotives) 4300 tons, are drawn up gradients of 0.3 per cent., the draw-bar pull under these conditions amounting to about 48,000 lb. The empty cars each weigh about 18 tons, the load of ore averaging 45 tons per car.

In the "all-steam-locomotive" days a "Mastodon" locomotive, weighing, with loaded tender, 141 tons, was accustomed to haul up this 0.3 per cent. grade fifty to fifty-five loaded ore cars at a speed of about 7 miles per hour. With fifty-five loaded ore cars the total train weight was about 3600 tons.

The speed of two 72-ton electric locomotives when hauling these 4300-ton trains up the 0.3 per cent. grade is about 16 miles per hour, or over twice as great as the speed of the lighter trains formerly hauled by steam locomotives.

"Drivers-to-Draw-Bar" Efficiency of Locomotives.—The term "drivers-to-draw-bar" efficiency of a locomotive may be defined as the percentage which the work delivered from the draw-bar of a locomotive constitutes of the work delivered from the rims of the drivers. Otherwise expressed—

$$\text{"Drivers-to-draw-bar" efficiency} = \frac{100 \times \text{draw-bar pull}}{\text{tractive effort}}.$$

There should be no need to discuss the obvious modifications of this definition, which are required when more than one locomotive is employed for hauling a train, or when an additional locomotive is employed at the rear of the train as a pusher.

Let us examine the "drivers-to-draw-bar" efficiencies of the electric and steam trains described above. On the basis of 6 lb. per ton for train resistance, the tractive effort required for the 4300-ton train, comprising two 72-ton electric locomotives and 4156 tons behind the draw-bar, is, on a 0.3 per cent. grade—

$$(0.3 \times 22.4 + 6) \times 4300 = 55{,}000 \text{ lb.}$$

Assuming that the frictional resistance of the locomotives, expressed in pounds per ton, is the same as that of the loaded ore cars—*i.e.*, assuming that it is 6 lb. per ton both for locomotives and cars, then the "drivers-to-draw-bar" efficiency for these conditions is—

$$\frac{4300 - 2 \times 72}{4300} \times 100 = 96.9 \text{ per cent.}$$

For the steam train representative of the practice on this road prior to electrification the total weight of the train was—

$$55 \times 63 + 141 = 3470 + 141 = 3611 \text{ tons.}$$

Again, assuming the same pound-per-ton friction for the locomotives as for the ore-cars, we have—

$$\text{"Drivers-to-draw-bar" efficiency} = \frac{3470}{3611} \times 100$$
$$= 96.2 \text{ per cent.}$$

Available data regarding the frictional resistance of locomotives are very meagre. In the absence of adequate data of the resistance of locomotives of various types, and at given speeds, statements of the "drivers-to-draw-bar" efficiency should be qualified with careful statements of the corresponding assumptions.

While for the case of heavy freight trains on easy grades the "drivers-to-draw-bar" efficiency is so high as not to constitute a factor of much importance, this is not the case for freight trains on heavy grades, or for high-speed passenger trains, as will appear from examples which will be given in the course of this paper.

In Fig. 3 is shown the profile of the 20 miles of main line between East Anaconda and Rocker. Below are given the results of two tests which have been carried

Fig. 3.

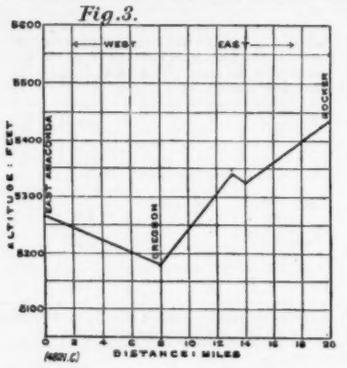


FIG. 3. PROFILE OF THE BUTTE, ANACONDA AND PACIFIC RAILWAY BETWEEN EAST ANACONDA AND ROCKER.

out to determine the power-consumption at the locomotives when running over this 20-mile section.

	Rocker to East Anaconda.	East Anaconda to Rocker.
Direction	West-bound	East-bound.
Distance	20 miles	20 miles
Number of cars in train ..	57 loaded cars	64 empty cars
Number of locomotives ..	2	2
Weight of each locomotive ..	72 tons	72 tons
Gross weight (including locomotives)	3700 ,,	1190 ,,
Gross ton-miles	74,000	23,800
Schedule speed	20 miles per hr.	20 miles per hr.
Total consumption	654 kw.-hr.	852 kw.-hr.
Consumption per ton-mile ..	8.8 watt-hours	35.8 watt-hours

It is interesting to attempt to segregate the energy-consumption measured on these tests. Let us first deal with the west-bound run. The schedule speed was 20 miles per hour, and the maximum speed was about 32 miles per hour. Practically the entire consumption of electricity occurs on the last 8 miles, from Gregson to East Anaconda, during which the train ascends 85 ft. Indeed, when the train enters upon this ascent the momentum-energy due to its speed is about 100 kw.-hours. We may assume that 30 kw.-hours of this momentum-energy offsets the electrical consumption from Rocker to Gregson, and that the remaining 70 kw.-hours relieves the motors (during the balance of the journey) by this amount. Since 1 kw.-hour = 2,659,000 ft.-lb., there will, for overcoming gravity through 85 ft., be required for the 3700-ton train :

$$\frac{85 \times 3700 \times 2240}{2{,}659{,}000} = 265 \text{ kw.-hours.}$$

The friction of trains of heavily-loaded ore-cars, expressed in pounds per ton, is very low, but in consideration of the frequent curves, it may for this journey be taken as 6 lb. per ton. Then the energy delivered from the motors to overcome friction during the journey amounted to—

$$\frac{6 \times 3700 \times 8 \times 5280}{2{,}659{,}000} = 355 \text{ kw.-hours.}$$

We now have—

	Kw.-Hours.
For overcoming gravity	265
For overcoming friction	355
Available from momentum acquired prior to commencement of ascent	70

The output from the motors during the 20-mile journey amounts to—

$$265 + 355 - 70 = 550 \text{ kilowatt-hours.}$$

The input to the locomotives was 654 kilowatt-hours. Of this amount (654 − 550 =) 104 kilowatt-hours represents the losses in the electrical equipment. The efficiency of the electrical equipment for the westbound journey was $\left(\frac{550 \times 100}{654} =\right)$ 84.0 per cent.

(To be continued.)

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below some data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

New Zealand : H.M. Trade Commissioner in New Zealand has forwarded extracts from the local Press, from which the following particulars are taken :—The ratepayers of Auckland have authorised the municipal authorities to raise a loan of 115,000*l.* for the purpose of carrying out the following works :—Erection and equipment of market buildings, 55,000*l.*; establishment of a fish market, 20,000*l.*; water supply in Grey Lynn, 10,000*l.*; construction of drainage works at Remura, 30,000*l.* It is also proposed to raise a loan of 75,000*l.* for improvement works at Epsom, as follows :—Installation of a system of storm-water drainage, 7000*l.*; purchase of plant for road-making, 1000*l.*; and general improvements to roads, 67,000*l.* A company has been formed for the erection of freezing works at Whakatane.

Ecuador : The *Registro Oficial*, Quito, publishes a Decree authorising the Municipality of the Canton of Mejia to sell certain lands in that district with a view to devoting the proceeds to the installation of a drainage and water-supply system in Machachi.

Bolivia : H.M. Chargé d'Affaires at La Paz has forwarded a translation of a Decree of the Bolivian National Congress, dated November 4, authorising the Executive to call for tenders for the construction of a railway from Potosi to Sucre. Tenders are to be on the basis of existing plans, and the Government are to guarantee interest up to 6 per cent. per annum on the capital employed in the work. The period for the presentation of tenders will close on June 30, 1916.

Argentina : The *Boletin Oficial*, Buenos Aires, publishes a Decree authorising the Empresa Vézin y Cía., of Paris, to extend the lines of the Central Northern Railway (State Railways) to the Argentine-Bolivian frontier, and to construct a bridge over the Quiaca River, thus connecting with the La Quiaca-Tupiza Railway which is under construction for the Bolivian Government by the same company.

"RUSSIA."—We have received the first number of the new journal *Russia*—the January issue. This journal is to be published, in English, monthly during the war, at the price of 6d. a copy, as the official organ of the Russian Chamber of Commerce in London, 16, Regent-street, London, S.W. The first number deals with the engineering prospects in Russia, with Russian industrial and commercial activity and contains also interesting articles on Russian life.

A SUBSTITUTE FOR MAGNESITE BRICKS.—We read in the *Iron Age* that a uniform and intimate mixture of granules of basic slag and dolomitic lime, about 10 to 90 parts respectively, is recommended by Albert P. Meyer as a substitute for magnesite brick, now so scarce, as a lining for furnaces of certain types. The suggestion is covered by a patent (U.S. 1,160,085) assigned to the A. S. Davison Company, Pittsburg, Pa. A hard, compact, dense variety of dolomitic limestone is recommended, preferably high in magnesia, which should be burned until sintered or semifused, as obtains in cement-clinker making, but with a higher finishing temperature, around 2800 deg. Fahr. The crude sintered granules of this lime are then mixed with granulated basic slag.

TELEPHONES.—Since the British Post Office undertook the construction and working of Government telephone lines there has been an enormous development of telephonic business. This is shown by the annexed table, indicating the number of telephones in working during each of the ten years ended with 1914 inclusive, and the number of trunk calls annually in the same period :—

Year.	Telephones.	Trunk Calls.
1904-5	32,995	15,547,226
1905-6	44,849	18,080,089
1906-7	54,476	19,915,217
1907-8	79,099	22,109,307
1908-9	86,744	23,623,594
1909-10	98,286	26,698,398
1910-11	121,730	30,236,458
1911-12	701,125	33,655,639
1912-13	730,763	36,019,086
1913-14	774,821	38,220,086

The revenue acquired year by year has advanced in a proportionate degree, the receipts for 1904-5 having been 804,535*l.*; for 1905-6, 1,049,202*l.*; for 1906-7, 1,214,694*l.*; for 1907-8, 1,383,180*l.*; for 1908-9, 1,522,442*l.*; for 1909-10, 1,750,308*l.*; for 1910-11, 1,952,537*l.*; for 1911-12, 2,962,736*l.*; for 1912-13, 5,785,701*l.*; and for 1913-14, 6,027,683*l.* The rapid progress observed during the three last-mentioned years is explained by the definitive acquisition by the Government of the local lines of the National Telephone Company. The trunk lines were purchased earlier.